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TABLE OF CONTENTS.

The 1928 Summer School for Engineering Teachers..... 521
Physics—Massachusetts Institute of Technology.
Electrical Engineering—University of Pittsburgh and Westinghouse Electric and Manufacturing Company.
The Summer School for Engineering Teachers (Continued)..... 522
English for Engineers at the University of North Carolina. A. C. Howell 621
The Annual Meeting:
The Problem of Engineering Education and the Small College. H. W. McKiel..... 629
Report of Committee No. 30, Orientation and Engineering Problems Courses. F. C. Dana, Chairman..... 641
Birthday Greetings. O. M. Leland..... 651
Remarks by President-Elect. R. L. Sackett..... 653
Farewell. H. S. Boardman..... 654
Symbols for Heat and Thermodynamics. Sanford A. Moss, Chairman 655
Regulations Respecting the Lamme Award..... 661
Local (University of North Carolina) Committees for 1928 Meeting 664
Encyclopædia Brittanica..... 664
New Members and Sections..... 665
Application Blank..... 666
1928 Year Book..... 667
Is the Society Known?..... 667

College Notes: i
Clemson College ii
University of Idaho ii
Sections and Branches:
Kansas-Nebraska iii
Kentucky v
Minnesota vi
South Dakota ix
Addresses Wanted xi

THE 1928 SUMMER SCHOOL FOR ENGINEERING TEACHERS.

H. P. HAMMOND,

Associate Director of Investigation.

Two sessions of the Society's Summer School will be held during the summer of 1928: one for teachers of physics and one for teachers of electrical engineering. The session on the teaching of physics will be held at the Massachusetts Institute of Technology, President S. W. Stratton of the Institute serving as Director. The session on the teaching of electrical engineering will be held at Pittsburgh, Pennsylvania, under the joint auspices of the University of Pittsburgh and the Westinghouse Electric and Manufacturing Company. Dr. F. L. Bishop of the University of Pittsburgh, Secretary of the Society, and Professor Charles F. Scott of Yale University, Chairman of the Board of Investigation and Coordination, will act as Co-directors of the Pittsburgh Session. Each of the sessions will be of three weeks duration and will probably begin about July 5. As in 1927, the only charge for attendance will be a registration fee of ten dollars. Each attendant, however, will pay his own expenses for transportation, room and meals.

Letters of inquiry and applications to attend should be addressed to H. P. Hammond, Room 605, Engineering Societies Building, 33 West 39th Street, New York City. Applications may be submitted at any time up to June 1 and those accepted will be notified promptly. Each session will be limited to an attendance of approximately forty. Applications will, in part, be considered in order of priority.

Further and more complete information as to the staff, program, housing arrangements and other details will be published in an early number of the JOURNAL.

PART III. PROCEEDINGS OF THE WISCONSIN SESSION *

Teaching Staff

Director: E. R. Maurer, Professor of Mechanics and Chairman of the Department, University of Wisconsin.

Secretary of the Conference: L. F. Van Hagan, Professor of Railway Engineering, University of Wisconsin.

Teachers of Mechanics

A. P. Poorman, Professor of Mechanics, Purdue University.

S. M. Woodward, Professor of Mechanics and Hydraulics, State University of Iowa.

Teachers of Laboratory Courses

H. F. Moore, Research Professor of Engineering Materials, University of Illinois.

M. O. Withey, Professor of Mechanics, University of Wisconsin.

Special Lecturers

Edward Bennett, Professor of Electrical Engineering, University of Wisconsin.

O. A. Leutwiler, Professor of Mechanical Engineering Design, University of Illinois.

C. S. Slichter, Dean of the Graduate School, University of Wisconsin.

E. M. Terry, Associate Professor of Physics, University of Wisconsin.

Stephan Timoshenko, Westinghouse Electric and Manufacturing Company.

F. E. Turneaure, Dean of the College of Engineering, University of Wisconsin.

Educational Adviser

Curtis Merriman, Associate Professor of Education, University of Wisconsin.

* Continued from the January, 1928, number of the Journal of Engineering Education.

PROGRAM

Monday, July 11

Forenoon. Registration.
1:30 P.M. Address of Welcome. Dean F. E. Turneaure.
The Purposes and Aims of the Summer School for Engineering Teachers. H. P. Hammond.
Mechanics of Engineering in the 19th Century. E. R. Maurer.
Organization of Committees.

Tuesday, July 12

8:30 A.M. Objectives in Mechanics. S. M. Woodward.
1:30 P.M. Some General Laws of Learning. Curtis Merriman.
3:00 P.M. Teaching Methods in Mechanics. E. R. Maurer.

Wednesday, July 13

8:30 A.M. Survey of Actual Teaching Practices in Mechanics. Curtis Merriman.
10:30 A.M. Written Work in Mechanics (Problems, Quizzes, etc.) A. P. Poorman.
1:30 P.M. Minimum Essentials in Mechanics. S. M. Woodward.
3:30 P.M. Group Seminars.

Thursday, July 14

8:30 A.M. Center of Gravity and Moment of Inertia. A. P. Poorman.
10:30 A.M. Group Discussion.
1:30 P.M. Lecture Demonstration Methods in Mechanics. E. M. Terry.

Friday, July 15

8:30 A.M. The Teaching of Friction. A. P. Poorman.
10:30 A.M. Group Discussion.
1:30 P.M. Laboratory Methods in Teaching Mechanics. E. M. Terry.

Saturday, July 16

Automobile trip to Devil's Lake and the Dells of Wisconsin; Hydroelectric plant en route.

Monday, July 18

8:30 A.M. The Teaching of Acceleration. E. R. Maurer.
10:00 A.M. Newton's Second Law. S. M. Woodward.
1:30 P.M. Combined Stresses. E. R. Maurer.
3:00 P.M. Computation Methods. S. M. Woodward.

Tuesday, July 19

8:30 A.M. The Teaching of Flexure Formulas. A. P. Poorman.
1:30 P.M. Inspection of Forest Products Laboratory.

Wednesday, July 20

8:30 A.M. The Teaching of Column Formulas. M. O. Withey.
1:30 P.M. General Comments on Preceding Model Presentations. Curtis Merriman.

Thursday, July 21

8:30 A.M. Factors of Safety: Working Stress. F. E. Turneaure.
10:00 A.M. Endurance Limit. H. F. Moore.
1:30 P.M. Planning and Conducting Courses in Materials Testing Laboratory. H. F. Moore.

Friday, July 22

8:30 A.M. Materials Testing Laboratory Demonstrations. M. O. Withey and H. F. Moore.
1:30 P.M. Materials Testing Laboratory Demonstrations. M. O. Withey and H. F. Moore.

Saturday, July 23

8:30 A.M. Conduct of Materials Laboratory Classes. H. F. Moore.

Monday, July 25

8:30 A.M. Structural Mechanics. F. E. Turneaure.
1:30 P.M. Application of Mechanics to Machine Design. O. A. Leutwiler.

Tuesday, July 26

8:30 A.M. Machine Design. O. A. Leutwiler.
1:30 P.M. The Rôle of Mechanics in Electrical Engineering Curricula. Edward Bennett.
Hydromechanics. S. M. Woodward.

Wednesday, July 27

8:30 A.M. A New Approach to Mechanics. Edward Bennett.
10:00 A.M. Mechanics of the Hydraulic Jump. S. M. Woodward.
1:30 P.M. Elasticity. S. Timoshenko.

Thursday, July 28

8:30 A.M. Advanced Dynamics. C. S. Slichter.
10:00 A.M. Laboratory Tests of a Column. M. O. Withey.
1:30 P.M. Elasticity. S. Timoshenko.

Friday, July 29

Committee Reports.
Summaries.
Discussion.
Adjournment.

Evening Meetings

Monday, July 11. Smoker.

Wednesday, July 13. Lecture: Liberal Learning and Mechanical Training. Glenn Frank, President, University of Wisconsin.

Thursday, July 14. Lecture: Science in the Orient. H. L. Russell, Dean, College of Agriculture, University of Wisconsin.

Monday, July 18. Lecture: Lessons from a Great Life (Sir Isaac Newton). C. S. Slichter, Dean, Graduate School, University of Wisconsin.

Wednesday, July 20. Lecture: Engineering Education and the Social Order. W. E. Wickenden. Director of Investigation, S.P.E.E.

Thursday, July 21. Lecture: The Historical Development of Mechanics. H. F. Moore, Research Professor of Engineering Materials, University of Illinois.

Tuesday, July 26. Lecture: Mineral Resources—Some of Their Political Aspects. C. K. Leith, Professor of Geology, University of Wisconsin.

Thursday, July 28. Lecture: Research in Engineering Colleges. A. N. Talbot, Emeritus Professor of Municipal and Sanitary Engineering, University of Illinois.

Monday, July 11. Afternoon Session

The Wisconsin Session of the Summer School was opened by Dean F. E. Turneaure, who welcomed the members to the University in a brief address. Director Maurer then took charge of the meeting and introduced H. P. Hammond, Associate Director of the Society's general investigation, who outlined the purposes and plans of the summer school and discussed the program to be followed in the sessions of 1927. Mr. Hammond's remarks were substantially the same as those delivered a few days previously at the opening of the Cornell Session. They are summarized in Part II, and will be found on page 376 of the January, 1928, issue of the JOURNAL OF ENGINEERING EDUCATION and on page 15 of Bulletin No. 14, *The Summer School for Engineering Teachers,* a separately bound volume which may be obtained from the Lancaster Press, Lancaster, Pennsylvania.

Following Mr. Hammond's introductory remarks, Professor Maurer addressed the meeting on

MECHANICS OF ENGINEERING IN THE NINETEENTH CENTURY AS REVEALED BY TEXTBOOKS OF THE PERIOD

It was his purpose, Professor Maurer said, to indicate something of the background of present methods of presenting the subject of mechanics and to introduce the study of methods of teaching it by considering briefly the methods employed in the last century. This he would do by describing some of the best known textbooks which appeared during that period.

The foundations of mechanics, he said, had previously been laid by Galileo and Newton. Other masters—Leibnitz, the Bernoullis, Euler and D'Alembert—had contributed materials for the superstructure, and Lagrange and Laplace had builded these and their own contributions into noble structures, or systems, of mechanics.

Some appreciation of the literature of engineering of the nineteenth century is afforded by an advertisement, to which Professor Maurer referred, dated 1837, which gives the titles of some three hundred works relating more or less closely to engineering. Besides a goodly number on mathematics there

are ten on mechanics, seven on steam engines, eight on railroads, three on bridges, one on masonry, and one on hydrostatics, as well as three on strength of materials. From among the various works then available, Professor Maurer selected six of the most notable for discussion. His list included Moseley's *Mechanics of Engineering,* Weisbach's *Mechanics of Engineering,* Rankine's *Applied Mechanics,* Wood's *Strength of Materials,* Wood's *Analytic Mechanics,* and Church's *Mechanics of Engineering.* These were published in the order named, the first appearing in 1837 and the last in 1887.

Taking up Moseley's book first, Professor Maurer commented on its great scope as compared with that of present texts on mechanics. The book is divided into six parts: *Statics, Dynamics, Theory of Machines, Stability of Structures, Strength of Materials,* and *Impact.* Of these, the longest section is devoted to machines and includes not only simple machines such as the wheel and axle, screw, pulley, and the like, but also gear teeth, bevel wheels, and belts (called *bands*). It also treats of the efficiency (called *modulus*) of appliances.

The section on structures deals almost exclusively with masonry structures, including arches, but makes brief mention of simple trusses.

The section on strength of materials discusses elasticity and elastic limit, though later in the book there are curious failures to appreciate the full significance of the elastic limit. Terms familiar in present nomenclature appear, but there is a curious usage of *strain* for the modern *stress.* Interesting descriptions are given of experiments for checking theories, a feature lacking in many modern books on this subject.

Statics is treated in small space, only forty pages, half of which relates to center of gravity and the properties of Guldinus. Several uses of terms and definitions which seem odd to us are found, including such as the following: "When forces are applied to a body in such wise that it rests, then they are called pressures." "The parallelogram of pressures," Moseley remarks, "constitutes the foundation of

the entire science of statics." Work is referred to as "the union of a continued pressure with a continued motion." "This union," he continues, "has received from English writers the various names of 'dynamical effect,' 'efficiency,' 'work done,' 'laboring force,' 'work,' etc." The state of flux through which terminology was going is clearly indicated. The same thing is true of units. Moseley refers, for example, to the proposal to use a single word, especially coined, for a unit for work. This he disapproves because he would "gladly shelter himself from the charge of having contributed to increase of the vocabulary of scientific words." Power is referred to as "accumulated work." Nevertheless the expressions for power and energy are correctly stated, though there is much confusion in the use of the terms *weight* and *mass*. The term $(W/g)v^2$ is referred to as the *vis viva* of a body, and the *accumulated work* is referred to as half the *vis viva*.

Continuing his discussion of Moseley's book, Professor Maurer took up the section on dynamics and pointed out what seem to us curious usages and methods as compared with those employed in more recent works. The differences of methods of study and of teaching which have developed in the last ninety years are easily inferred from the different methods of treatment of the subject in texts which have appeared in that interval.

Professor Maurer then turned to Weisbach's *Theoretical Mechanics*, which appeared in Germany in 1826 and was later translated into English. Weisbach's work is also of great scope and size in comparison with modern texts. It is in three volumes: *Theoretical Mechanics, Heat and Steam Engines*, and *Kinematics and Mechanics of Transmission*. The first volume alone comprises over one thousand pages, and includes an array of Parts and Sections, and many chapters and articles, all of which might be grouped under the modern titles of *Analytic Mechanics, Strength of Materials*, and *Hydraulics*. Weisbach's treatment of his subjects is indicated by the preface to his original edition in which he writes, "If we consider how many subjects a technical man must master in order to accomplish anything very important in his pro-

fession, we must make it our business as teachers and authors for technical men to facilitate the thorough study of science by simplicity of diction, by removing whatever may be unnecessary, and by employing the best known and most practicable methods. For this reason I have entirely avoided the use of the calculus in this work." It is worthy of note, however, that in his later editions, Weisbach employs the calculus where needed, though he states that he has made it "as popular as possible."

Weisbach begins mechanics proper, Professor Maurer said, with *phoronomics,* or *kinematics,* as we would say. Much of the treatment is elementary, quite detailed, and limited to cases of constant velocity or acceleration, though his concept of these quantities is the modern one. Curious and seemingly careless uses of terms and units appear, particularly in dealing with velocities and accelerations which are frequently expressed simply in *feet.*

Professor Maurer characterized the treatment and definitions of fundamental quantities of mechanics throughout the book as, in general, good. He pointed out a number of deficiencies, however, such as the definition of weight, concerning which Weisbach writes "pressure, traction and weight are quantities of a *peculiar* kind and can be compared only with themselves."

Weisbach's section on *Strength of Materials* was said to show marked improvement over previous authors on that subject. Stress-strain diagrams are employed and there is much discussion of safe loads and factors of safety. Tables on tensile and compressive strengths and on shearing strength are included. Flexure and horizontal shear formulas are developed correctly, though cumbersomely. Euler's formula is given for columns, though the author apparently fails to recognize, on theoretical grounds, that it is limited to slender columns.

Rankine's *Applied Mechanics,* Professor Maurer said, will long remain the classic on the subject. Twenty editions have appeared since its first printing in 1858. Like other older works on mechanics, it includes more than do recent ones.

In addition to statics, dynamics and kinematics, it includes structures (with strength of materials), mechanism and machines. Rankine's presentation is notable for its clearness but is so concise in many places that it is far from easy reading.

Professor Maurer spoke briefly of the works of Wood and Church, American writers of comparatively recent years. Their books, he said, include a smaller range of subject matter than did those of their predecessors. "Why did these men," he asked, "cover smaller fields? Undoubtedly a partial explanation is this: Engineering was differentiating; mechanical engineers were appearing on the scene, and then came professors of special divisions or departments of engineering —structural, steam, hydraulics, machine design, etc. The authors among them took over, as it were, their own portions of applied mechanics and left the remainder to be taken care of by others."

Reference was also made to still more recent books, including Lanza's *Applied Mechanics,* Burr's *Elasticity,* and Merriman's *Mechanics of Materials.* The latter, Professor Maurer said, was notable for its lucidity.

Professor Maurer concluded his address by considering what may be done in the treatment of mechanics in the twentieth century, and stated that he believes that sometime and somehow there will be developed a notable advance in the presentation and teaching of mechanics for engineers. This desideratum, he said, will be accomplished by someone with a genius for teaching, a master of the subject, and one who will be thoroughly acquainted with the field of its application. He expressed the hope that the summer conference on mechanics might hasten the event.

Following Professor Maurer's address, the appointment of general committees of members was announced as follows:

ADVISORY COMMITTEE, to cooperate with the staff:

W. E. Brooke, *Chairman,*
J. H. Robert,
J. C. McKinnon.

COMMITTEE ON RECORDS:

L. F. Van Hagan, *Chairman,*
L. N. Field,
S. B. Folk,
A. S. Hansen,
F. C. Hartwich,
H. J. Kersten,
W. B. Johns, Jr.,
F. G. Person,
F. R. Stewart,
G. P. Stocker,
Edward Taylor,
LeRoy Tucker,
I. F. Waterman,
K. F. Wendt.

RECREATION COMMITTEE:

B. Spieth, *Chairman,*
E. R. Dawley,
C. F. Gross,
Banks McLaurin,
F. H. Wade,
K. F. Wendt,
C. A. Wiepking.

After a brief intermission, Professor S. M. Woodward introduced the subject of his topic of the following day, *Objectives in Mechanics,* by asking the members before the next meeting to prepare written statements of those objectives which they considered of sufficient importance to be reflected in programs and methods of conducting courses.

Monday, July 11. Evening Meeting

A smoker was tendered to the members of the conference by the faculty of the College of Engineering. A short program of instrumental music was followed by an illustrated talk given by Professor Daniel W. Mead on the geological history and formations of the Madison region. Each member of the conference was also called upon to say something about himself and his institution.

Tuesday, July 12. Morning Session

At the opening of the meeting the formation of a group of committees was announced. Each committee was assigned a topic relating to the teaching of mechanics which it was requested to study and report upon toward the end of the conference. Each member was appointed to one or more of these

committees. The intention was to have an important part of the study of teaching methods done through these committees. The membership follows:

1. Correlation of Analytic Mechanics with Other Subjects: LeRoy Tucker, *Chairman,* R. D. Campbell, A. S. Hansen, H. E. Mayrose, F. G. Person, A. P. Poorman.

2. Minimum Essentials in Analytic Mechanics: M. H. Snyder, *Chairman,* H. R. Boykin, W. E. Brooke, J. C. McKinnon, K. F. Wendt, S. M. Woodward.

3. Classroom Methods: Edward Taylor, *Chairman,* D. M. Bavly, H. J. Kersten, P. T. Norton, Jr., C. A. Wiepking, S. M. Woodward.

4. Written Tests in Analytic Mechanics: R. S. Tait, *Chairman,* L. M. Becker, S. B. Folk, Banks McLaurin, N. H. Winde, A. P. Poorman.

5. Home Problem Work: G. P. Stocker, *Chairman,* C. H. Cather, L. N. Field, F. C. Hartwich, I. F. Waterman, E. R. Maurer.

6. Sample Problems in Analytic Mechanics: W. B. Johns, Jr., *Chairman,* E. R. Dawley, H. E. Pulver, F. R. Stewart, S. M. Woodward.

7. Apparatus for Teaching Analytic Mechanics: F. H. Wade, *Chairman,* A. Fick, T. E. Pettengill, Benjamin Spieth, E. R. Maurer.

8. Organization and Administration of Courses in Analytic Mechanics: J. H. Robert, *Chairman,* C. F. Gross, E. E. Moots, W. W. Wegner, A. P. Poorman.

9. Objectives in Teaching Analytic Mechanics: S. B. Folk, *Chairman,* D. M. Bavly, H. E. Hartig, M. K. Snyder, F. H. Wade, H. B. Wilcox, S. M. Woodward.

S. M. Woodward: OBJECTIVES IN TEACHING MECHANICS.

Professor Woodward conducted the meeting by first holding a general discussion of the topic, calling upon the members in turn to express their views and to read the statements of objectives which had been prepared in response to his request. The discussion dealt chiefly with the following questions:

1. Why are all engineering students required to take an extensive course in mechanics?

2. What different kinds of skill or ability are the students expected to acquire, and to what degree of proficiency are they expected to attain in these various skills?

3. How much should be required in the memorizing of definitions, meanings, constants, laws, demonstrations, symbols, formulas?

4. How much skill should be required in ability to derive formulas that have not been memorized?

5. How much skill should be required in ability to translate "story problems" into algebraic equations?

6. What skill should be expected in algebraic transformations and solutions of equations?

7. What facility in the use of trigonometry, analytic geometry, and calculus should be required?

8. What standards of form, legibility, and accuracy in numerical computation should be insisted upon?

9. What standards of oral and written composition should be expected?

Commenting upon these topics, Professor Woodward felt that the student should be given a convincing reason why he should be required to take an extensive course in mechanics; it is necessary to do this to command his respect for the subject and to arouse his interest in it. He should also be told quite definitely what standards of work will be expected of him, including such matters as neatness, accuracy of computation, memorizing of certain definitions, meanings of laws, symbols and formulas, reproduction of derivations, and the like.

In connection with methods of study and with requiring the student to understand clearly all parts of the text, Professor Woodward said that he has the student who encounters difficulty in understanding a passage read it over aloud to him until he reaches the first word that he does not understand. Often the very suggestion that the student read the passage clears up the difficulty. At other times the trouble may be that the student does not understand a particular word, or that the text is at fault. In such cases, it is not difficult to set the student straight.

Professor Woodward believes that teachers should point out those parts of the text which are so important that they

must be completely mastered. Other parts requiring less complete mastery should also be indicated. It is essential, in his opinion, that students learn to translate problems which are stated entirely in words—story problems—into equation form. He also feels that the equipment of mathematical training which students beginning the study of mechanics should possess should be clearly and accurately defined.

The standards of form, neatness, and legibility for submission of problems and other written work should, in Professor Woodward's opinion, conform to those of regular engineering practice.

Among the points brought up in the discussion of objectives was the question of the practical versus the theoretical approach to the subject. It was generally agreed that the theory of mechanics should be stressed, but that illustrative problems should be practical in nature so that the student will see the bearings of what he learns.

The importance of the study of mechanics as means of training in methods of work and clearness and accuracy of thinking was also stressed.

Tuesday, July 12. Afternoon Session

Curtis Merriman: Some General Laws of Learning.

Professor Merriman addressed the conference on this topic as the first of a series of discussions of general educational principles and methods. His address followed the outline of topics which appears below.

1. What is learning?
   - *a.* Many technical definitions, all probably true, but difficult to apply.
   - *b.* We shall use: Learning is the process of becoming able to do something which we previously could not do.
   - *c.* This homely definition provides a means of checking progress; it leads to the acid test of a lesson period: Do students know something or are they able to do something worthwhile at the end of the period which they did not know or could not do at the start?

2. Kinds of learning.
   a. Current practice has suggested elaborate outlines.
   b. Present tendency toward a functional and simple division.
   c. Suggested types:
      (1) By teaching for habits and skills we shall mean those activities which have for their purpose the fixing of facts, processes or laws in the mind of the learner so that when one element of the fact or process is presented another one comes into action automatically;
      (2) By teaching for knowledge and creative work we shall mean those activities which have to do with the discovery and understanding of new facts, new principles, new processes;
      (3) By teaching for appreciation and inspiration we shall mean those activities which have for their purpose the development of interests, tastes, ideals and ambitions.
   d. These three types are certainly involved in
      (1) Engineering in general,
      (2) Mechanics,
      (3) Any complete education, whether wholly cultural or professional.
   e. This three-fold training will produce engineers who
      (1) Will be able to do the habitual thing in a skillful way;
      (2) Will be able to analyze, understand, and do the new and unusual thing;
      (3) Will be anxious to grow.

3. Are there any conditions or factors that appear to be involved in all learning, regardless of type?
   a. Law of *effect*. The individual tends to repeat and learn quickly those reactions which are accompanied or followed by a satisfying state of affairs. He tends not to repeat or learn quickly those reactions that are accompanied or followed by an annoying state of affairs.
   b. Law of *readiness*. When the nervous system is ready to act, for it not to act is annoying and for it to act is satisfying. When the nervous system is not ready to act, for it to act is annoying and for it not to act is satisfying. This law involves questions of maturity, prerequisites and mind-set. Of these three, mind-set is most under direct control of the teacher.

c. Law of *exercise.* When a bond between a situation and a response is used, other things being equal, the strength of that connection is increased. When a bond between a situation and a response is not used during a period, the strength of the connection is decreased.

d. Law of *distribution of exercise.* The strengthening effect of the exercise of a bond depends upon the distribution of the exercise, and, other things being equal, the maximum effect is secured through distributed effort rather than through concentrated effort.

e. Law of *general intelligence.* The subject's capacity to learn contributes to the effect of the exercise of a connection between a situation and a response.

4. What is a teacher's function in this learning process?

a. Note function of school and education in general as a phase of the significance of infancy. Note Fiske and Dewey's *Philosophy.*

b. A suggested sequence of functions of the teacher.

(1) To discover what students want to do and on the basis of present status of wants, guide their activities so that they will want to do those things which are most educative.

(2) To devise and select appropriate learning exercises. This will save the learner from becoming lost in the maze of costly trial and error.

(3) To assign these exercises.

(4) To motivate the doing of the exercises.

(5) To give advice and suggestions in regard to doing them.

(6) To evaluate (test) the learner's achievement.

(7) To devise and assign supplementary exercises, when the test shows incomplete mastery.

(8) To give direct assistance when it is really needed.

c. A suggested "test check" of a teacher's skill in lessons.

(1) Check up on preparation of assigned work.

(2) Correct wrong ideas.

(3) Add new information.

(4) Make adequate assignment of new work.

(5) Provide inspiration for attack upon new problems.

5. What are some of the type methods of securing information and knowledge?

a. Through *experience* (including observation and expression). Results of survey of teaching methods in me-

chanics (to be discussed later) suggest we are short in this respect Lack of laboratory exercises, difficulty in visualization, etc.

b. Through *development.* (Explanation, development, reasoning, etc.)

(1) Defining the problem.
(2) Collecting the data.
(3) Tentative conclusions and hypotheses.
(4) Verification and application.

Note: These steps relate to the old Herbartian idea; to inductive-deductive lessons; to desirability of having all lessons fit one form, etc.

c. Through *reading.* Survey of purposes of reading. To understand, to remember, to find information, to criticize author, to supplement the text, to analyze the text, to enjoy.—Monroe.

d. Through *use.* Relation to drill and new material.

(1) In drill. Stimulus and response constant.
(2) In new. Stimulus and response variable.

Note: Difference between having large or small ability in these four fields tends to make the difference between the great engineer and the mediocre one. The purpose in suggesting the point here is to see whether we are looking ahead far enough in our teaching. Are we teaching technicians, or are we teaching Keplers, etc.?

6. What is the relation of the general theory to some of the prevailing practices, devices, etc.?

a. The project method—various ideas about meaning of project. May be physical—material, learning, intellectual, etc. All unite, however, in presence of felt, purposeful activity.

b. Improvement of memory. All mnemonic devices may be evaluated in terms of these general laws.

c. Place of attention. Nothing mysterious about attention. It, too, comes under the head of problem consciousness.

d. Socialized recitation.

e. Provision for individual differences.

f. Interest in improvement.

g. Use of standard tests and scales.

h. Specific practice in function to be improved.

i. Forgetting.

j. Fatigue.

A TEACHERS' CREED

7. Can we summarize the foregoing into a teachers' creed?
   a. I believe that all new work must be presented upon the foundation provided by previous work.
   b. I believe that learning should be accompanied by the maximum amount of satisfaction and that this satisfaction can be measured by its relation to the fulfillment of wants and plans.
   c. I believe that interest and effort should be rooted in natural motivation rather than in spectacular or fear bases.
   d. I believe that material which is to be used many times in fixed form should be reduced to the habit level.
   e. I believe that material which is to be used many times in both fixed and variable forms should be "overlearned."
   f. I believe that there should be recognition of the optimum distribution and arrangement of drill periods.
   g. I believe that the formation of habits and securing of knowledge depend upon the standard of efficiency set by the learner, and that we must keep these standards of mastery high in order to counteract the tendency to get along with minimum effort.

Professor Merriman's lecture was followed by general discussion.

E. R. Maurer: TEACHING METHODS IN MECHANICS.

Professor Maurer said that he would consider the above topic by explaining his own methods, and that he would then call upon other members of the group to explain their methods.

He touched first upon the objectives of the course in analytic mechanics which he characterized both as training in fundamental engineering principles and methods which are useful in themselves, and as preparation for engineering subjects to which analytic mechanics is prerequisite.

He then described his customary procedure in conducting classes. Definite assignments of text material, with or without problems, are given for each period. Occasionally some preliminary explanation of the material assigned is given. The first step in each class period is questioning of the stu-

dents concerning the subject matter of the lesson with the purpose of obtaining a general summary of its content. Demonstrations of principles and derivations of formulas are then taken up, the instructor working at the board and keeping up a running fire of questions. The students themselves are sometimes asked to give the proofs, in which case two or three students are asked to give the same proof in the hope that one good one may result. Professor Maurer finds that students can not as a rule give demonstrations or proofs well, and that they seem to be getting less proficient in this respect. Problems are often assigned in lieu of proofs. Usually the problems called for are those assigned for the day's work. Occasionally, if the students have solved the assigned problems successfully, new ones are given. If the class, as a whole, has failed to solve the assigned problems, the instructor himself solves them, the class cooperating.

Professor Maurer said that his students are advised to keep notebooks. The books are not corrected or graded but are used as a basis for conference. These conferences he finds very beneficial.

Unannounced written quizzes are given frequently; usually about once in eight days. Proofs and derivations are required and the use of textbooks is not permitted. Papers are graded and returned the next day if possible, and the questions are discussed with the class. Final examinations consist almost wholly of problems. Use of textbooks is not permitted.

After Professor Maurer's remarks, there was general discussion. The first point mentioned was that of posting complete schedules of assignments for courses at the beginning of the term. Practice in this respect differed, as did opinion as to its value and propriety. Other points mentioned were the amount of mathematical analysis which is desirable in problems, the giving of "surprise" quizzes, and the use of the short written quiz at each class period.

Tuesday, July 12. Evening Meeting

Glenn Frank: Liberal Learning and Mechanical Training.

Liberal learning to-day, President Frank said, is in a state of turmoil, and educators are in a state of disillusionment as a result of the great volume of knowledge piled up during the past century. New knowledge has come too fast for educators to digest and correlate it. Perhaps just as civilizations collapse when social problems become greater than they can bear, so liberal learning may collapse unless some way can be found to control the situation. There is need for a more intelligent correlation of knowledge with the needs of actual life.

Turning from the field of liberal learning to that of scientific and technical education, President Frank stated that intensive specialization is dominating education with unhappy results. The scientist becomes too narrow to conceive the broad visions that produce epochal scientific advance; the man of affairs fails to keep the policies of state and nation in proper perspective, to control conditions, and to achieve safety and sanity in the social order. Students who specialize find swiftly changing conditions rendering their specialty obsolete, and teachers lose their effectiveness when specialization becomes the master instead of the servant.

President Frank characterized the present age as one of science but not a scientific age. Men do not think scientifically outside of the field of their specialities. The man who is master of scientific methods in his researches may descend to the mental level of the stable boy when he turns his mind to local politics. Scientific training is not creating the habit of thinking scientifically under all conditions.

In spite of the frequently expressed opinion that the accumulation of knowledge is so great that no man can know everything, President Frank stated his belief that in any field of knowledge the elements that vitally affect society are few and can be stated simply, so that it should be possible to give students a fair understanding of them.

The ideas embodied in these statements were developed by President Frank in some detail and their implications with reference to educational principles and the organization of educational institutes were traced out.

He concluded his address with an account of the experimental college to be established at the University of Wisconsin in the fall of 1927 under the leadership of Dr. Alexander Meiklejohn.

Wednesday, July 13. Morning Session

Curtis Merriman: SURVEY OF ACTUAL TEACHING PRACTICES IN MECHANICS.

The entire morning was devoted to presentation of the results of a survey of teaching methods in mechanics made by Professor Merriman to furnish data for his discussion of educational principles as applied to work in mechanics. The survey was conducted by means of two questionnaires sent respectively to teachers and to students of mechanics. The questionnaire circulated to students was answered by 688 students in the Universities of Wisconsin, Minnesota, Purdue, Iowa, and Illinois. That circulated to teachers was answered by sixty-nine teachers in twenty-nine representative institutions, mostly in Middle Western states. The results constitute a fairly comprehensive picture of methods employed in teaching mechanics and of the "state of mind" of students and teachers to the work.

Professor Merriman began his presentation by reading the questions of the two forms and then giving the tabulated responses. Running comments were made on each of the replies and the speaker was frequently interrupted by questions. Complete tabulations of the results of the studies are given in Part IV. The following condensed digest summarizes some of the more important results.

1. The typical teacher of mechanics is an assistant professor with his second degree.
2. He has taught eight and one-half years. His sections number from eighteen to twenty students.

3. Division of students into sections is made arbitrarily (usually on an alphabetical basis) without reference to ability.
4. Recitation periods are fifty minutes in length.
5. Notebooks are not required to be kept, although the practice is usually recommended.
6. Examinations are prepared by the instructor himself in small institutions. In large institutions they are usually prepared by a committee.
7. About five pages of text and from three to five problems are usually assigned as a lesson.
8. Students are graded for the work in the course on the basis of
   a. Ability to pass examinations,
   b. Ability to solve problems and exercises,
   c. Mastery of theory and demonstration of formulas.
9. In general, the following percentages of students receive the grades indicated:
   a. Failed 10
   b. Poor 25
   c. Average 50
   d. Excellent 15
10. Teachers believe that students who fail do so because
   a. They lack ability;
   b. They do not work;
   c. They lack the necessary preparation in prerequisites.
11. The most important reason for including courses in mechanics in engineering curricula, as given by teachers of mechanics, is that it is a "case" subject which provides training essential as preparation for engineering subjects which follow it.
12. The average time required by students to prepare a lesson in mechanics is two hours.
13. The kind of interest of students in mechanics is fairly typical of that in most other subjects. As a rule, the students find the class hour of more interest than the study period.
14. Teachers demand a reasonably thorough mastery of the subject.
15. Students rate their teachers of mechanics "above average" in comparison with teachers of other subjects.
16. Mechanics is taught better, in students' opinions, than are English, mathematics, and science.
17. Students feel that teachers of mechanics are often ambiguous in their statements and devote too much time to exceptions and irrelevancies.

Commenting upon the results of the survey, Professor Merriman pointed out that teachers of mechanics, as a rule, are well qualified in experience and preparation; presumably, mechanics is taught by capable men. Weaknesses in present-day methods, as indicated by the results, he said, were chiefly failure to connect principles with practical illustrations, the effort to crowd too much work into the allotted time, and the selection of learning exercises that are not typical. Attention was called to the fact that the teachers laid the blame for student failures entirely upon the students, or they appeared to do so since they listed only such factors as lack of capacity, lack of application, and inadequate preparation. Members of the group added the comment that poor teaching should have been added to this list of causes.

Commenting constructively upon the results of the study, Professor Merriman raised the question as to whether teachers of mechanics should not take upon themselves the duty of motivating students. "Do we," he asked, "make sufficient use of the sense of mastery as a source of satisfaction to the student and thus motivate his work? Is the student really made to feel the joy in a good piece of work well done?" In this connection, he called attention to the fact that the first lessons of a course are important in the matter of motivation and orientation. It is then that the student should be given an appreciation of and a liking for the subject.

Favorable comment was made upon the reactions of the students to their work in mechanics in comparison with other subjects and to the estimates they place upon the abilities of teachers of mechanics. In general, Professor Merriman felt that the conditions indicated are satisfactory. A fair proportion of the students, however, feel that the quality of their teachers and of the instruction offered is not satisfactory, indicating some unevenness in this regard.

Wednesday, July 13. Afternoon Session

A. P. Poorman: Written Work in Mechanics.

Written work in mechanics, the speaker said, should be planned so as to accomplish two aims: first, to contribute to the student's mastery of the elementary principles of the subject, to develop his ability to analyze situations, to assemble the mathematical tools necessary to a solution, and to proceed with the solution with speed and accuracy; second, to provide the instructor with a record of the student's achievement. The first is the primary and the other the secondary purpose.

Professor Poorman then discussed in some detail the various methods which may be employed in written work.

Home problem work was discussed first. Such work, he said, forces the student to learn the theory of the lesson, because he will need it in solving the problems. Further, it sets a definite task which must be done to avoid penalty. The danger, however, is that the student will spend all of his time on the problems and fail to study the theory except just enough to solve the problems in a mechanical way. Further, it is difficult to include in a reasonable assignment of problems enough material to cover the entire lesson. Home work also conduces to copying. Grades on home work are therefore likely to be very unreliable, thus defeating the second objective of written work.

Blackboard work was then considered. Its advantages are manifest: The psychological effect of standing at the board and working at a problem is very good—mistakes are easily erased and the instructor can give needed assistance. Independent blackboard work should be required, necessitating the assignment of different problems to different students. Among the disadvantages of blackboard work is the difficulty of examining all of the work during the period and pointing out mistakes as they are made.

Another method of conducting written work, which Professor Poorman has found superior to either of the above, was then discussed. Class periods are divided into two parts. In

the first thirty minutes or so the class-discussion method is used, the teacher explaining the various aspects of the lesson and keeping up a running fire of questions as he proceeds. Questions raised by the students are answered and difficulties are cleared up. No attempt is made to give grades on these oral recitations and the work is somewhat informal. After the period of discussion half-sheets of paper are passed out and a problem is assigned which is to be solved in the remaining twenty minutes or so of the period. Preference is given to problems which force the student to use his initiative as well as his knowledge and will not permit him to substitute blindly in a formula. Reference to textbooks is permitted. After the class period the papers are examined, mistakes indicated and grades given. The papers are returned at the next meeting and the problem is then explained. Since the student knows that he will be tested on the work of each lesson he has the "want to know" attitude both in studying and during the class discussion. The problem selected is chosen with the idea of fixing the fundamental concepts of the lesson in the student's mind. This method is working very satisfactorily, in Professor Poorman's opinion, not only aiding the student to master the fundamental principles of mechanics but also giving the instructor an accurate record of the student's performance. It is not claimed, Professor Poorman said, that the method has all virtues and no defects. Some students are inclined to try to get their work with little previous study, relying mainly upon the discussion which precedes the problem work to enable them to "get by." This objection, however, is more apparent than real, in his opinion, for it makes little difference how the student gets his work as long as he really gets it.

Professor Poorman discussed the tendency among both teachers and students to treat each lesson largely as an entity in itself. In order to avoid this, periodic tests are given which cover fairly distinct divisions of the subject. At Purdue seven such tests are given during the semester, each test occupying fifty minutes. About half of the tests consist of one deriva-

tion and one problem, and the remainder of two problems. Definitions are occasionally called for.

In conclusion, the final examination as a form of written work was discussed. When first introduced, Professor Poorman said, its avowed aim was educative; to force on the student a comprehensive view of the entire semester's work. Assistance given to the instructor in gauging the student's performance was incidental. As examination practices have worked out, however, the second objective has been given greater emphasis. This leads to the question: Is the educative value of examinations properly capitalized?

S. M. Woodward: Minimum Essentials in Mechanics.

The talk was prefaced by remarks upon general methods pursued by the speaker in his teaching. What he termed "artificial methods" are avoided as much as possible. Problems are realistic, and are chosen from the field of actual engineering practice. Standards and methods employed in engineering offices are followed as nearly as is possible in a college. Students are taught to abstract and summarize their work as they proceed. This is an art in which they need to be instructed; they need to learn how to get the essential material out of their texts. Assistance is given to students only after they have made the effort to learn for themselves.

The term *minimum essentials*, Professor Woodward said, is given different interpretations by different people. In his opinion, it should include those things that every practicing engineer must know and use without hesitation; for example, he should know exactly what $F = Ma$ means, or what g stands for and its numerical value. It should cover that body of material which is to remain with the student permanently. Unless he knows these essentials perfectly he should not be passed in the course; a grade of sixty or seventy per cent in essentials should not be tolerated. All courses, to be sure, include other matters than the basic essentials and a grade of sixty or seventy on these other matters may be satisfactory. The student should be explicitly informed, Pro-

fessor Woodward feels, as to just what the essentials are and should record them in his textbook. Further, he should understand that he will be required to know them thoroughly.

The following outline was presented by Professor Woodward as indicating his own ideas as to the minimum essentials of statics:

Introductory. Definitions: Vectors, free body, Newton's laws of motion, transmissibility of forces.
Concurrent co-planar forces. Definitions: Concurrent, co-planar, component, resultant, rectangular components, moment of a force.
Parallelogram law.
Triangle law.
Resolution and composition of forces, graphically and algebraically.
Varignon's theorem.
Comparison of methods.
Parallel co-planar forces.
Couples.
Resolution of a force into a force and a couple.
Composition of a force and a couple.
Non-concurrent, non-parallel co-planar forces.
Parallel forces in space.
Conditions of equilibrium.
Center of gravity. Principle of moments.
Composite bodies, addition and subtraction.
By integration.
Moment of inertia. Definitions.
Parallel axis rule.
Relation between rectangular and polar moment of inertia.

Discussing this outline, Professor Woodward felt that it is best to take up specific cases first and then the conditions of equilibrium, thus viewing the subject from the physical rather than the mathematical aspect. Most students, he said, prefer physical conceptions. The idea of resultant force needs to be emphasized at the very beginning. Co-planar forces should be presented before forces in space. The method of composite bodies should precede the method of integration.

Professor Woodward does not announce assignment schedules for the entire course but does set a limit on the assign-

ments so that the section composed of the best students finishes the course in less than the allotted time. Problems are examined but not graded. Students who show that they have solved the first problem without really understanding it are asked to do another. Accuracy is insisted upon. The idea of grades is kept rather in the background as far as students are concerned and is mentioned only occasionally and casually.

After Professor Woodward's presentation the conference divided into three groups for seminar discussion of the subject, *Minimum Essentials.*

Seminar Group 1. **E. R. Maurer, Leader.**

In opening the discussion, Professor Maurer said that he believes that teachers in general do not enforce the rule that a student must know all essentials completely. Most teachers, he said, will not fail a student if he can not demonstrate one essential and is able to demonstrate the others.

Various items of Professor Woodward's outline of essentials in statics were then discussed. *Forces in space* would be included by a majority; *comparison of methods of analysis* would not. The *analysis of the catenary* was suggested as an essential but was voted down. There was considerable discussion as to the inclusion of *Newton's laws of motion* in statics which developed differences of view as to the essential approach to the subject of statics, some considering it proper to deal with statics as a special case of motion. The majority, however, felt that only Newton's third law should be included in statics. No consensus of opinion was reached on the matter as a whole.

Seminar Group 2. **S. M. Woodward, Leader.**

The discussion turned largely upon the question of whether or not, in view of varying conditions in colleges throughout the country, it is practicable to establish a list of minimum essentials. Some took the view that the uses of mechanics in engineering are such that essential principles must be mastered

irrespective of the type of institution or preparation of its students. Others held that the needs of the students are the controlling factor and the requirements should be varied accordingly. The consensus of opinion seemed to be that essentials in mechanics are so important that mastery of the fundamentals must be achieved.

The discussion then turned to various items of Professor Woodward's outline. It was felt that *comparison of methods* should not be included in a list of minimum essentials.

Seminar Group 3. **A. P. Poorman, Leader.**

At the beginning of the meeting attention was given to an apparent difference in the amount of time which students at Purdue University devote to preparation of lessons in mechanics in comparison with students of other institutions. Three possible reasons for this difference were discussed: (1) Purdue students may employ superior methods of study; (2) the students may have learned "to beat the system"; (3) the two hours commonly required elsewhere may be more than necessary. In view of the fact that the work in mechanics at Purdue is known to be of high grade there was considerable interest displayed in this matter but no satisfactory conclusion was reached.

The discussion of minimum essentials was brief and only a few of the items of the outline were considered.

Thursday, July 14. Morning Session

A. P. Poorman: CENTER OF GRAVITY AND MOMENT OF INERTIA.

The morning was devoted to a model presentation of one division of statics, the topic selected being *Center of Gravity and Moment of Inertia.* Professor Poorman presented the subject in much the same way as he would to a class of students, but also interjected explanations of his methods as he proceeded.

Before discussing the topic chosen, Professor Poorman said that it should be one of the duties of teachers of mechanics to

offset a tendency among students to regard the subject as a very difficult one. He characterized this attitude as a "fear complex," and gave an account of how the attitude of students at Purdue toward the subject had been changed through improved methods of presenting it and through organized efforts to orient classes to its nature and value.

In dealing with the subject, *Center of Gravity,* Professor Poorman explained how it is possible to give students a physical conception of center of gravity and expressed the belief that this method of approach is helpful. In dealing with the center of gravity of a plane area, for example, a thin plate may be used. It may be shown how the plate can be divided into parts and the principle of moments, which may be summed up in a catch phrase "the sum of the moments equals the moment of the sum," can be applied. The student has no difficulty, he said, in seeing that the weight of the entire plate times the distance from its center of gravity to a given axis is equal to the sum of the products of the areas of the parts of the plate and the distances from their individual centers of gravity to the given axis. It is also obvious that the weight of the plates and the weights of its parts are proportional to the corresponding areas so that we may write the equation

$$A\bar{x} = a_1x_1 + a_2x_2 + a_3x_3 + \text{etc.}$$

When this physical conception of center of gravity has been given, the calculus method may be employed, and such problems as the location of the center of gravity of the quadrant of a circle, the segment of a parabola, and the like, can be solved. Professor Poorman explained that in considering areas, more than one method of integration may be used, such, for example, as the selection of a differential strip or a differential sector, instead of the differential area $dx\,dy$.

Throughout the presentation of the topic, Professor Poorman indicated that the students may be led to the proper conclusions through questions and thus reason the steps out as the demonstration proceeds.

As a final step in the classroom work on center of gravity,

problems may be given involving cross-sections of machine parts and other complex areas, as practical applications of the principles.

In discussing the principles of moment of inertia, Professor Poorman explained that it is his purpose first to give the student as clear a conception as possible of the meaning of the process of integration upon which the determination of the moment of intertia depends. This may be done, if it is felt necessary, he said, by applying an arithmetic method to a rectangular area. The entire area may first be multiplied by the square of the distance between its center of gravity and an assumed axis. The rectangle may then be divided into halves by a line parallel to the assumed axis and the sum taken of the products of the areas of the two halves and the squares of the distances from their centers of gravity to the axis. This may be repeated by assuming smaller and smaller subdivisions of the area, thus approximating more and more closely to the result obtained by integration. Professor Poorman felt that such presentation, though elementary, might constitute a valuable introduction to the subject.

He then indicated how the moments of inertia of simple areas may be obtained by the method of integration.

The same procedure was followed with radius of gyration. Professor Poorman indicated how the student may be led clearly to understand that the radius of gyration is merely the square root of the average of the squares of the lever arms of portions of the area.

The method of transferring moment of inertia from an axis through the center of gravity to a parallel axis was also considered, as well as the solution of a number of problems involving combinations of areas, such as a semicircle and a rectangle. In these cases, Professor Poorman said, it is advisable to have the students work with actual numerical problems instead of with problems merely involving symbols or letters.

As to the desire of students for a physical conception of moment of inertia, he said that this can not be satisfied since the moment of inertia is a fourth dimensional quantity.

Following Professor Poorman's presentation, the conference divided into seminar groups for further discussion of the teaching of principles of statics.

Seminar Group 1. **E. R. Maurer, Leader.**

Several members of the group questioned the advisability of introducing the subjects of center of gravity and moment of inertia by arithmetical analysis. In their opinion, students of mechanics should be required to employ the calculus at the very start, both because the method of the calculus leads to much clearer analyses and because the students should be required to employ the principles and methods of subjects previously studied.

The matter of motivation of students of mechanics was considered. It was felt that the best motivation is work of a stimulating nature which arouses and maintains their interest. The use of problems relating to real engineering situations was felt to be highly desirable. The view was also expressed that too obvious effort toward motivation is disliked by students.

The matter of classroom methods in presenting center of gravity and moment of inertia and the use of blackboard work was considered. It was thought by some that apparatus might be used to advantage in illustrating the principle of moment of inertia, but others felt that this does not lead to valuable results since the moment of inertia is not susceptible of physical interpretation.

Seminar Group 2. **S. M. Woodward, Leader.**

There was considerable discussion of the possibility of finding physical concepts for moment of inertia and of using apparatus to illustrate it in a physical way. No satisfactory conclusion was reached, however, since the moment of inertia is an abstract term. There was also some discussion of including the study of dynamic balance in minimum essentials in analytic mechanics but the opinion concerning it was adverse.

Seminar Group 3. **A. P. Poorman, Leader.**

After some discussion of the preceding model presentation, the subjects of written work, notation and methods of grading were considered and a number of practices were discussed. Professor Poorman concluded the meeting by explaining the methods of grading papers and keeping records of students' achievement used at Purdue University.

Thursday, July 14. Afternoon Session

E. M. Terry: LECTURE DEMONSTRATION METHODS IN MECHANICS.

Professor Terry demonstrated a number of experiments which are used to illustrate the teaching of elementary mechanics in the course in physics which is given to sophomores at the University of Wisconsin. Lecture demonstrations are a part of the course which also includes recitations and laboratory exercises.

Professor Terry opened his discussion by commenting upon the relation which exists between the teaching and study of mechanics as a part of the course in physics and the teaching and study of analytic mechanics. He referred to the difficulty of getting the fundamental concepts of physics thoroughly implanted in students' minds.

Professor Terry first spoke of demonstrations relating to motion, and showed how the student may be led to correct ideas concerning the relationships between time, distance, speed and acceleration. Velocity and acceleration are demonstrated by the speed of a train or automobile since these come within the range of the students' experiences. Actual observations of train and automobile speeds are employed and the results of field tests are plotted and analyzed both graphically and analytically.

That a body may have two simultaneous components of motion, neither influencing the other, is illustrated by an experiment with two balls. The first rolls down a curved track that terminates at a point several feet above the floor. At the end

of its motion down the track the ball is moving horizontally. At the end of the track it strikes a trip that releases a second ball held at the same elevation. The two balls thus fall freely although one has an initial horizontal motion. The experiment is so arranged that one ball strikes the other before reaching the floor, thus indicating that their vertical motions have been exactly the same.

Professor Terry demonstrated experiments used to introduce the subject of simple harmonic motion, and then passed to dynamics. Several demonstrations illustrating Newton's second law were given. Simple experiments indicating the inertia forces both of solids and of liquids were shown. Professor Terry also demonstrated how concepts of mass and weight can be shown from simple tests. It is difficult, he said, for students to get correct concepts of kinetic energy, the difficulty lying not so much in the development of the equations as in their physical significance. Tests which he has found of value in this connection were demonstrated. Centrifugal force is approached through centripetal force, the experiment used in this connection being a rotating vessel filled with a colored liquid.

Turning to the study of statics, Professor Terry demonstrated how ideas of parallel forces and couples may be demonstrated. He also discussed demonstration methods of teaching moment of inertia.

Professor Terry's demonstrations were followed by general discussion of the laboratory work incident to courses in mechanics.

Thursday, July 14. Evening Meeting

H. L. Russell: SCIENCE IN THE ORIENT.

The Orient, Dean Russell stated, has adopted occidental science and applied it to oriental conditions. Japan and Java stand out as two countries whose scientific advance has been startling. In Japan, for example, the strong, centralized government has been able to develop the silkworm industry remarkably and to insist that each of the 3,300,000 families en-

gaged in silkworm culture raise nothing but pedigreed stock. Another indication of the strength of science in Japan is found in the Chemical-Physical Institute in Tokio, a private laboratory that receives some government support. The institute is only five years old, but it has a staff of 250 scientists and an annual budget of $250,000. It seeks practical applications for scientific discoveries, and from one item alone its annual royalties amount to $75,000. In Java, agriculture is intensely specialized and is completely dependent upon scientific control. Each industry—sugar, rubber, tea, coffee, tobacco, and quinine—maintains its individual experiment station, supported by the industry and not by taxes.

Friday, July 15. Morning Session

A. P. Poorman: THE TEACHING OF FRICTION.

When the student begins the study of friction in analytic mechanics he is likely, Professor Poorman said, to think of it as an agent whose principal function is to reduce motion to rest. The first step in teaching the subject should be to call attention to the usefulness of friction. An automobile, for example, is able to start only because of friction between its wheels and the ground. The next step is to eradicate a very common notion that friction is a force acting at all times and equal to the normal force between two bodies times the coefficient of friction. The fundamental concepts of static and of kinetic friction should be fully explained and their significance made plain by illustrations.

In connection with the teaching of friction, Professor Poorman finds that the graphic method is of great service, both because it conserves time and because it assists in making the trigonometric relations plain. For classroom graphical work, Professor Poorman has each student provide himself with a small draftsman's triangle and a decimal scale. To illustrate the use of the graphic method Professor Poorman demonstrated the solution of the conventional problem of a body resting on an inclined plane and acted upon by a force making an angle with the plane. In his demonstration, he indicated

the types of questions which may be used to lead the students themselves to take the steps required in the solution. The first is the preparation of the free-body diagram. The second is the selection of the coordinate axes. The next step is the setting up of an equation between the upward and downward vertical forces, this form of equation apparently causing fewer errors in signs than any other. Professor Poorman was interrupted at this point by a number of questions as to practices in the matter of affixing signs and as to methods of clearing up student difficulties in that connection. The consensus of opinion was that his method is preferable to others. The demonstration was then resumed, Professor Poorman indicating how a graphical solution may be carried on at the board by the instructor while the students work at their seats, the blackboard work affording a reasonably accurate quantitative check of the results.

Following the presentation of graphic solutions, the method of algebraic analysis was taken up. In dealing with the angles involved in problems on friction, Professor Poorman wrote out the numerical values of the functions from the dimensions of the figure instead of expressing them first as the sine, cosine, etc. This he felt is the preferable procedure when the subject is first studied. In later problems he would employ angles such that it would be necessary to consult a table of functions in order to obtain values needed.

The demonstration of teaching friction was followed by seminar discussion.

Seminar Group 1. **E. R. Maurer, Leader.**

The discussion centered around the relative merits of graphical and analytical methods. Several of those present stated that groups of students in different courses showed different abilities in the use of the graphical method. Some students find it a difficult medium of solution, others (civil engineers and architects were cited as examples) are usually able to use graphical methods with facility. It was felt that the course in analytic mechanics should use the analytic method and that

graphical analyses should be left very largely to other courses. Opinion was about equally divided as to the desirability of the graphical method as an introduction to work in friction.

Seminar Group 2. **S. M. Woodward, Leader.**

The discussion included a variety of points connected with the teaching of friction: relative usefulness of graphical and analytical methods; emphasis to be placed upon the angle of repose; representation of vectors so as to form simple and clear diagrams; affixing of signs; nomenclature; approximate or free-hand sketches *vs.* drawings made to scale; and the estimation of approximate numerical results before making the actual computations. The conference concluded with a brief discussion of the elements of trigonometry which students should have at their command in order to solve problems in mechanics with facility.

Seminar Group 3. **A. P. Poorman, Leader.**

The group considered, from the standpoint of form and difficulty, the type of problem that should be given to students in daily quizzes, preparatory to taking up new matter. A number of problems of this type were offered for consideration by members of the group and were discussed. One point of agreement among the members was the necessity of having the student understand clearly that the value of the frictional force under given conditions depends upon the forces acting, and that its limit is fixed by the coefficient of friction.

Friday, July 15. Afternoon Session

E. M. Terry: LABORATORY METHODS IN TEACHING MECHANICS.

The members met at the Sterling Laboratory of Physics and were conducted through the laboratory by Professor Terry who explained the apparatus and methods employed in the laboratory course which accompanies the classroom work of the first course in physics. Special attention was devoted to the experiments dealing with mechanics. In this part of the

course students are required to perform sixteen experiments upon which they submit reports written out of class hours. Students are permitted to perform more than the required number of tests and a bonus is given in grades for those who complete more than the required quota.

Various devices for demonstrating the principles both of statics and dynamics were shown. Professor Terry explained, in particular, a device consisting of a light derrick for illustrating the composition and resolution of forces. The derrick has a compression balance for a boom and other members are adjustable so that problems involving different numerical quantities can be solved. Other apparatus included a force table, a couple bar, inclined planes, torque equipment, and apparatus for demonstrating centrifugal force. The Baer apparatus for determining the acceleration of gravity was also demonstrated. During the exhibition of the equipment Professor Terry explained methods of conducting the tests which are assigned to students.

Saturday, July 16

The day was devoted to recreation. The members visited the Wisconsin Dells at Kilbourn, fifty-six miles north of Madison, making the trip by automobile. The Summer Surveying Camp of the University, located at Devil's Lake, was visited en route, and a stop was also made at Mirror Lake. At Kilbourn, a division was made, some of the party visiting power plants along the Wisconsin River, while the others took a boat trip through the Dells.

Monday, July 18. Morning Session

E. R. Maurer: The Teaching of Acceleration.

Professor Maurer chose the subject of acceleration because of its difficulty to students and the variety of methods for its presentation. He explained that the demonstration would be based on the supposition that students had learned something of motion in the courses in physics and mathematics.

Professor Maurer devotes six exercises to the study of motion in order to prepare students adequately for the further study of dynamics. Rectilinear motion is taken up first because it is relatively simple. Some teachers, however, prefer to take up curvilinear motion first and to treat rectilinear motion as a special case of curvilinear motion in the belief that the student will thus be led to realize more fully that acceleration is not always given by the equation $a = dv/dt$. Professor Maurer stated that in the present meeting he would take up curvilinear motion first and return to rectilinear motion later.

In dealing with motion, Professor Maurer emphasizes the vector feature of velocity. Since students ordinarily have not studied vector analysis before taking analytic mechanics it is necessary to develop the idea of the rate of change of a vector quantity from the beginning. This may be done, very much as in the case of scalar quantities, from the average rate idea. Professor Maurer explained the hodograph and solved numerical examples of motion in a circular path. The hodograph, he stated, is not a practical device for determining acceleration but is simply a very good teaching device.

The resolution of acceleration into axial and tangential components was touched upon, after which Professor Maurer returned to the subject of straight-line motion and presented a series of motion graphs which he uses for the purpose of having students describe motion in words rather than by symbols and formulas. The graphs were speed-time, velocity-time, and acceleration-time diagrams. The case of the falling body was used to illustrate the difference between time rate of change of velocity, which is acceleration, and space rate of change of velocity, which is not acceleration.

S. M. Woodward: Newton's Second Law.

Students are uncertain, Professor Woodward said in beginning his explanation of the presentation of the second law of motion, in applying the elementary equation $F = Ma$. In order to make the concept of this law perfectly clear and to give the student confidence in applying it to a variety of cases,

Professor Woodward deals with it in a very concrete way, proceeding from illustrative problems to general principles. He begins, for example, by asking the students to consider the top of the desk as a frictionless surface upon which a one hundred pound weight rests. The class is then asked to imagine that a horizontal force of one hundred pounds is applied to the weight and to state what will happen. Rarely, Professor Woodward said, will any student be able to give the correct answer because he does not recognize the law $F = Ma$ when applied in this way. If the equation is written $a/g = F/W$, the student sees very clearly that the acceleration of the body will be equal to g, or 32.2 feet per second per second. If forces other than one hundred pounds are applied, the acceleration will be in proportion. After the first example has been fully discussed, the students are asked to consider a train of four blocks, each weighing twenty-five pounds, to which a force of twenty pounds is applied (figures illustrating these cases are, of course, placed upon the blackboard). From the previous example the students know that the acceleration is $\frac{1}{5}\ g$, but a new idea is introduced by asking them to find the tensions in the strings connecting the several blocks. They are then told that they can isolate each body and the proportion $a/g = F/W$ applies to the whole system or any part of it. After this problem has been solved, it is modified by allowing the last twenty-five pound block to be suspended vertically by a cord passing over a pulley, and the tensions in the strings are then recomputed.

Another question asked of the students is: What upward force must be applied to a body weighing ten pounds so that it will accelerate like a falling body?

All of these questions, Professor Woodward said, are very elementary and the numerical work is such that it can be done by mental calculation. They illustrate the sort of questions that ought to be used for extensive oral drill until every student sees the relation of force and acceleration in all sorts of problems instantly instead of regarding the relation as one to be expressed only by algebraic formula.

Following Professor Maurer's and Professor Woodward's demonstrations, the conference divided into three groups for informal discussion. It seemed to be the opinion of the majority that Professor Maurer's demonstration of acceleration involved more calculus and algebraic computations than most instructors use. It was also felt that the hodograph is a difficult device for students to understand. Different methods of presenting tangential and normal components of acceleration were demonstrated, including, among others, that used by Poorman in his *Applied Mechanics*. The use of the terms *mass* and *weight* were discussed at some length, the conclusion being that teachers of mechanics are little interested in the controversy concerning the use of these terms and that they tend to use the term *weight*.

The question of whether to introduce only one or several new ideas into an illustrative problem was raised by Professor Merriman, who said that he had gathered the impression that teachers of mechanics give an illustration for each new idea. The consensus of opinion was that illustrative problems should be kept as simple as possible and that new concepts should be taken up one at a time. All except one of the teachers present take up rectilinear motion before curvilinear motion.

Monday, July 18. Afternoon Session

E. R. Maurer: COMBINED STRESSES.

This was the first of several meetings devoted to the discussion of topics ordinarily considered in courses in mechanics of materials.

Combined stresses, Professor Maurer said, mean different things to different persons. In mechanics of materials, the student soon becomes acquainted with the stress on vertical and horizontal sections of beams. This case, therefore, may serve to introduce the subject of combined stresses by considering the stresses on inclined sections of beams.

The formulas for this case are developed in class by what might be called "cooperative reproduction" of what is in the textbook. The students study the text but most of them fail

to understand this subject satisfactorily without some assistance in the classroom. In considering the problem, some element in the beam is taken and the forces acting upon it are considered. The stress on any inclined section of the element is then determined, from which the sections of greatest normal stress and greatest shearing stress are found. General equations are developed first and the student is then given numerical problems and asked to find the stresses.

The main problem is to find the planes upon which the stresses are greatest and to determine the values of those stresses. When the formulas have been worked out, they are applied to beams and shafts and numerical problems are solved. Students are shown that the "nominal" stresses which they have previously regarded as the greatest in beams and shafts are not, in all cases, the greatest ones. The class is usually somewhat disturbed when they learn this but it is explained that such cases are rather exceptional although the designer should be fully aware of them.

S. M. Woodward: COMPUTATION METHODS.

At the time of his graduation, Professor Woodward stated, an engineer should be a good computer; neat, accurate, and rapid. These qualities should have been developed in him in college. Methods of developing these qualities, he said, would constitute the subject matter of his remarks.

In his own practice, letter size paper is used for problems; work is done upon one side only and must be in ink. The name and date are written at the top and the student is told the importance of dating all papers so that they may be fully identified later. This is insisted upon, he stated, until it becomes a habit; a practice which every engineer should follow. In all cases, he said, the students are required to submit their original computation sheets with the idea of having the original work done neatly instead of having it scrawled or sloppily done. The original pages must show all of the computations. Students are trained to make liberal use of sketches. Freehand sketching is permitted but it must be neatly done. Script instead of printed letters and figures may be used in computation work if desired.

Emphasis is laid upon correct methods of using logarithms. The students are taught to interpolate mentally. They use a four-place table of logarithms in their computations.

There is a definite effort to develop the student's judgment about the matter of significant figures in which results should be expressed and to train them in appreciation of the proper degree of refinement to be used. Textbooks, Professor Woodward said, often fail to mention these matters and are themselves not consistent in their practices.

Professor Woodward then considered a number of matters connected with computation work; among them the method of solving quadratic equations. He insists upon students following the practice of completing the square rather than substituting in formulas which give the result. All of these points are taken up in the three-hour study periods devoted to mechanics at the University of Iowa. These periods are a combination of supervised study and recitation during which the student does all of the work required in the course. Since the students are all working under observation, it is possible to insist upon the practices mentioned. Instruction in computation methods is given during the first exercises of the course so that the student fully understands just what is expected of him.

Monday, July 18. Evening Meeting

C. S. Slichter: LESSONS FROM A GREAT LIFE.

Dean Slichter's address on Sir Isaac Newton is printed in full in Part IV, which will appear in the March, 1928, issue of the JOURNAL OF ENGINEERING EDUCATION, and will also be found on pages 230 to 249 inclusive of Bulletin No. 14, *The Summer School for Engineering Teachers*, a separately bound volume which may be obtained from the Lancaster Press, Lancaster, Pennsylvania.

Tuesday, July 19. Morning Session

A. P. Poorman: THE TEACHING OF FLEXURE FORMULAS.

The first step in presenting flexure formulas to students, Professor Poorman said, should be to point out the assumptions on which they rest and their limitations. Relation be-

tween the internal stresses and the moments due to the external forces on beams is then derived, step by step. A beam of some particular cross-section, usually not a rectangle, is chosen and the portion to the left of an assumed section is considered as a free body. In addition to the shearing force on the section, a stress couple must be introduced to balance the moment of the external forces. This will be an internal stress considering the beam as a whole, but it will be external so far as the free body is concerned. The couple must act in such a way as to produce compression at the top, or concave side, of the beam and tension at the bottom, or convex side, of the beam. It is an observed fact that deformations vary uniformly from one side of the beam to the other, hence if the elastic limit is not exceeded, stresses also vary uniformly. Since the stresses constitute a couple, there must be a change of sign from one side of the beam to the other and between the two there must be a neutral surface on which there will be no deformation and no stress. Professor Poorman continued by demonstrating how the intensity of stress at various distances from the neutral axis may be found and also how the moment of the stress on the cross-section may then be equated to the moment of the external forces and the flexure formula established.

After discussing the teaching of flexure formulas, Professor Poorman presented the results of a test made at Purdue University to learn whether there is any relationship between the grades which students achieve in mathematics and physics and those which they receive in mechanics. The correlations between the grades were shown by means of charts, and were found to be very high.

The whole matter of grading systems was then opened for discussion. Professor Woodward raised the point that grading systems involve a considerable element of chance. Examination questions, he said, can include only a few of the elements of subject matter of a given course. The selection of these units for examination involves a good deal of chance and the result may not yield a fair indication of the student's actual achievement. It was pointed out by others, however,

that the questions chosen for examinations nearly always deal with essentials. This greatly reduces the element of chance. The question was then raised as to what is meant by a grade of 70 per cent. Does it mean that the student has mastered 70 per cent of the content of a course, or does it mean that he has a 70 per cent knowledge of all of it, or does it mean simply that he is able to achieve a grade of 70 per cent on a definite set of questions in a definite time? If so, how important is the time limitation and how representative are the questions? It was thought that the final examination, as a rule, is a fair index of the per cent of content of a course which the student has acquired. While it is a factor in some cases, speed is not a very important element in the usual type of examinations since most teachers assign questions which can be answered by an average student within the allotted time. In connection with Professor Poorman's analysis of grades in mechanics and the prerequisite subjects, the question was raised as to whether the grades achieved in previous subjects should influence the teacher in assigning grades in mechanics. There was also a question of whether grades in previous subjects should be used in part as a basis of advice to students to continue or to drop a given subject. The discussion of these questions was general in nature and no specific conclusion was reached.

Tuesday, July 19. Afternoon Session

The afternoon was devoted to a trip of inspection to the Forest Products Laboratory as a part of the recreation program.

Wednesday, July 20. Morning Session

At the beginning of the session Professor Woodward presented a digest of a paper entitled, *The Learning Process*, which was presented by Mr. Donald D. Curtis to the Society at its annual convention in June, 1927. The paper gives the results of a study made at the University of Iowa to determine the range of speed of learning of students of mechanics. The outstanding result was that slow men sometimes need four or five times as much time as fast men to master a given assign-

ment. It was also shown very clearly that grades vary inversely with the time required for study; the fast men achieving high grades and the slow men low grades. The study was conducted under carefully controlled conditions in three-hour supervised study periods. It was thus possible to keep accurate records of the time and to verify the students' knowledge of the assignment by recitations held immediately upon completion of the study periods. The investigation also disclosed that assignments often considered of equal difficulty require different amounts of time by good and poor students alike. Whether or not the observations indicate completely the ultimate grasp of the subject which students obtain, they do show plainly a very wide spread in the facility with which students study.

Professor Woodward's description of the investigation was followed by a general discussion during which attention was given to the sectioning of classes on the basis of ability. In certain cases where sectioning has been practiced it has been found impossible to get the faster students to cover more ground in the time allotted to a course than the slower students. Premium for more intensive work has therefore been given by permitting the faster sections to complete the work at an earlier date.

M. O. Withey: The Teaching of Column Formulas.

This was one of a number of meetings devoted to the study of the subject matter of mechanics of materials. Professor Withey showed, in detail, how column formulas are taught by him.

If the class is composed of poor students, Professor Withey said, a brief introduction to the subject of columns is given prior to the assignment of the first lesson; if composed of good students this procedure is not followed. After acquainting the students with the three classes of compression members—prisms, short columns and long columns—attention is directed to the principal assumptions concerning columns and to the factors which most influence column strength: slenderness ratio, end restraint, and eccentricity of load.

The Euler formula is taken up first. Attention is directed to the critical load and a simple experiment, which Professor Withey demonstrated as he spoke, is used to illustrate this point. Common failure of the students to appreciate the significance of the Euler formula has led Professor Withey to emphasize that it shows: (1) that the restraint at the ends of a long column exercises a great influence on its strength; (2) that the strength varies directly with the modulus of elasticity of the material and with the moment of inertia of the cross-section; (3) that the strength varies inversely with the square of the length. Professor Withey then demonstrated the derivation of the Euler formula in full as he does to a class.

Various other formulas for maximum loads on columns are considered and the students are then given a written quiz. These quizzes, when short, usually consist of one or two questions, such as proof of a formula, the derivation of a special straight line equation or a problem. If the quizzes are long, three questions are asked, one of the three usually being a demonstration or a derivation.

Working formulas are then taken up. The student is taught to appreciate the uncertainties involved in end conditions, initial eccentricity and the location of points of application of loads. The factors of safety to be introduced in order to provide working formulas are next considered and a strong effort is made to impress on the student the idea of the factors of safety as commonly used in column design. Students frequently ask, Professor Withey said, what formula should be used in a particular problem. His reply is that if none is specified the student must select the formula himself and must justify his choice in accordance with the conditions.

In the solution of problems involving the choice of column sections, it is explained that strength, cost, durability, ease of making connections and occasionally appearance are the chief considerations. It is explained to the students that these factors must always be considered in practice though in the beginning course of study sections of maximum radius of gyration and minimum weight will usually be chosen.

Professor Withey's lecture was followed by numerous questions, many of which dealt with the problems assigned in connection with columns. The use of the secant formula was also considered. Professor Withey explained that the work on columns is given in eight or nine class exercises.

Wednesday, July 20. Afternoon Session

Curtis Merriman: GENERAL COMMENTS ON PRECEDING MODEL PRESENTATIONS.

The session was devoted to comment by Professor Merriman on his observations of the model lessons given by members of the staff at previous meetings. The following mimeographed outline of his statements was distributed.

1. What is the purpose of an observation lesson?
   - *a.* To suggest appropriate subject matter.
   - *b.* To suggest developmental steps.
   - *c.* To demonstrate how to recall apperceptive basis.
   - *d.* To provide methods of making and using illustrations.
   - *e.* To illustrate the progressive development through the successive steps named under *b*. Some authors suggest the following as a general formula:
     (1) Defining the problem.
     (2) Collecting the data.
     (3) Tentative conclusions and hypotheses.
     (4) Verification and application.
   - *f.* To demonstrate methods of meeting unusual situations.
   - *g.* To stimulate the observers and participants to experiment with different methods. Discussion of observation lessons should enable the new teacher to avoid even trying methods that are unsound in both theory and practice.

2. Assuming, for the moment, that most lessons can be analyzed to show the general form in *e* above, which of these steps usually tests the teacher's skill the most?
   - *a.* Most of the lessons observed have handled steps (1), (2), and (4) quite well.
   - *b.* The hard thing is step (3). The teacher either does too much himself, or the student appears to lack the mastery insight into the problem.
   - *c.* In actual practice, teachers are often too lax in the language requirements along the line of definitions

and statements of laws and principles. The real teacher knows when the student is getting real mastery and when he is just memorizing.

3. What have I observed relative to questions and questioning?
   a. Very few *yes* and *no* questions.
   b. Usually each question has a definite content.
   c. Questions large enough to demand some topical responses.
   d. Incorrect responses accepted for the time and student compelled to pursue his position to the place where he is made to face his own inconsistency.
   e. Monroe and Carter have suggested the following types of questions for study by the teacher who is seeking to analyze and improve his teaching skill. Public school illustrations are suggested. The teacher of mechanics should devise a question to match each of the public school illustrations.
      (1) Selective recall, basis given. Example. What do New Zealand and Australia sell in Europe that may interfere with American markets?
      (2) Evaluating recall, basis given. Name the three statesmen who have had the greatest influence on economic legislation in the U. S.
      (3) Comparison of things on a single designated basis. Compare Russian and French armies as to leadership.
      (4) Comparison of two things in general. Compare the track construction of the early railroads with that of recent railroads.
      (5) Decision for or against. Whom do you admire more, Lincoln or Roosevelt?
      (6) Causes and effects. Why does New York have more tall buildings than New Orleans?
      (7) Explain the following statement. Quote statement.
      (8) Statement of relationship. What is the relation of exercise to good health?
      (9) Give an original illustration of a certain law or principle. Quote law.
      (10) Classification. What is the principle involved in a certain described situation.
      (11) Discussion. Discuss the Monroe Doctrine.
      (12) Criticism. Quote a sentence, or make a reference and ask for a criticism as to adequacy, accuracy, relevancy, etc.

4. What practices relative to questioning are *usually* regarded as the "best form"?
   a. State question and then name student.
   b. As a rule, avoid *yes* and *no* questions.
   c. Avoid repeating question or answer.
   d. Look directly at student. Be really interested in what he has to say.
   e. Insist that the student get beyond the place where he says: "I know, but I can't tell it." In most cases he does not know.

5. Suggested problems in learning for study by teachers of mechanics.
   a. Factors and conditions in achievement.
      (1) Variation in achievement due to general intelligence.
      (2) Variation in achievement due to size of classes, size of school, and to differences in teaching conditions.
      (3) Variations in achievement due to classes meeting three, four or five times a week.
      (4) Comparative achievement in classes with and without concurrent registration in some form of applied laboratory course in mechanics.
      (5) The validity and reliability of available prognostic tests.
   b. Methods of instruction and measurement of progress.
      (1) How much pre-explanation to give for text assignments.
      (2) Does student gain in ability to interpret theory at approximately the same rate he learns to solve problems?
      (3) What light would a study of errors made by advanced students throw upon procedure to be used in teaching the core subjects.
      (4) Would it be possible to devise some kind of standard test for the purpose of comparing achievement of classes in different schools?

6. Selected bibliography on psychology of learning.
   a. Pyle—*Psychology of Learning.* Warwick & York.
   b. Robinson—*Practical Psychology.* Macmillan.
   c. Monroe—*Directing Learning in the High School.* Doubleday, Page.
   d. Ruch and Stoddard—*Tests and Measurements in High School Instruction.* World Book Co.

e. Book—*Learning How to Work and Study Effectively.* Ginn & Co.

f. Miller—*Creative Learning and Teaching.* Scribner.

The first point which led to discussion was that teachers are inclined to present a conclusion or hypothesis themselves instead of leading the student to reach conclusions by his own reasoning. Professor Merriman intimated that teachers are inclined to be impatient with slow students and with poor statements and to present the matter under discussion correctly themselves. He was asked whether it is proper to allow students to make incorrect statements and in reply said that they should not be left with an incorrect conclusion but should be led by further questioning to the correct one. Professor Merriman also said that students might be asked to give original illustrations of laws or principles. Some of the members felt that this is very difficult to accomplish. One comment, for example, was that most teachers spend considerable time trying to find good illustrations and feel well satisfied when they are successful. Can students be expected, therefore, to suggest them offhand? Other comments, however, were to the effect that students often volunteer illustrations which they consider appropriate and that this indicates not only the desire to interpret principles in the light of their own experience but also shows some ability in that connection.

The usefulness of the *true-false* and *yes-no* type of questions in connection with work in mechanics was discussed and it was the feeling that these forms of questions, while stimulating, and of some usefulness, should not be adopted universally.

In his remarks Professor Merriman advocated the practice of first stating the question and then naming the student from whom an answer is expected. This led to a rather lively debate. It was Professor Merriman's belief that the plan of a recitation should not be mapped out so rigidly as to make deviations impossible; that, for example, the preparation of questions in written form for an ordinary classroom might be suitable at times, but, in general, did not give sufficient flexibility.

The suggested problems in learning to be studied by teachers of mechanics, given in division 5 of Professor Merriman's outline were emphasized as of more basic importance than matters of grading and classroom procedure. "The real thing," Professor Merriman said, "is to delve into the thinking processes of the student; the teacher should pay more attention to the operation of the student's mind in its learning processes."

Wednesday, July 20. Evening Meeting

W. E. Wickenden: ENGINEERING EDUCATION AND THE SOCIAL ORDER.

Dr. Wickenden spoke on the same topic as at the Cornell Session of the School and a brief summary of his address is given in Part II and will be found on page 431 of the January, 1928, issue of the JOURNAL OF ENGINEERING EDUCATION, and on page 70 of Bulletin No. 14, *The Summer School for Engineering Teachers,* a separately bound volume which may be obtained from the Lancaster Press, Lancaster, Pennsylvania.

Thursday, July 21. Morning Session

F. E. Turneaure: FACTORS OF SAFETY.

The morning was devoted to a discussion of factors of safety and working stresses. Dean Turneaure treated the subject from the point of view of the structural engineer and Professor H. F. Moore dealt with repeated stresses.

"Factors of safety really receive little attention in courses in mechanics," Dean Turneaure said, "although it would seem proper to give the student some introductory understanding and some appreciation of this important matter." In engineering design, factors of safety are of fundamental importance. Sometimes they involve other things than loads and stresses. Failure to estimate properly the capacity of a spillway or the height of a flood is a failure to provide a proper factor of safety. In some respects, he said, the term *margin of safety* is better than the usual term.

In engineering design safety comes first and economy sec-

ond, and as our knowledge of design increases factors of safety can be decreased; we can design with greater economy. The tendency to-day in standard specifications for structural designs is not to mention the factor of safety but to specify the loads, materials and working stresses. To determine allowable working stresses is the real job of the engineer; after they have been determined by the best engineering talent, lesser men can do the designing.

The following are some of the elements that affect working stresses: variations in material, corrosion and deterioration, uncalculated stresses, probability of unusual combinations of loads.

The total stress on any member caused by all loads must be below the yield-point but as close to it as possible since working stress is based primarily on yield-point strength. The minimum and not the average value of the yield-point strength of a given material must be used.

Allowance must be made for corrosion by adding to the thickness of the material and not by reducing the working stress. Some stresses are so difficult to calculate that they are often ignored, though they may amount to a considerable percentage of the calculated stresses.

The logical way to provide for a future increase in live load is to plot the curve of increases from past records, decide upon the profitable life of the structure and then estimate the proper load. Dean Turneaure cited the field of railway bridge construction as an illustration of this and said that past practice has been to discount the future and to hide the real strength of structures by using low working stresses. In this way engineers may have been more far-sighted than executives who often refused to permit the use of large loads in design but did permit the use of low stresses so that bridges would stay in service a reasonable length of time. In recent years when many engineers have become managers, working stresses have been increased.

Dean Turneaure concluded his presentation by showing some special cases of factors of safety which arise in bridge designing.

H. F. Moore: Endurance Limit.

Professor Moore began his lecture by stating that engineers are sometimes criticized by physicists for using the factor of safety but that there are four considerations which make it probable that the engineer will never be able to design up to the full limit of strength of his materials. They are: (1) Low stresses repeated a great many times may cause failure; (2) there will always be some doubt about the properties of materials; (3) loads cannot be fully known; mechanics of materials is not a finished or exact science; (4) provision must be made for accidental overload.

The factor of safety, Professor Moore said, is a part of the engineer's philosophy. He must take the nice processes of mathematics and apply them to imperfect materials and uncertain loading conditions.

Taking the designing of machines as a field for illustration of his remarks, Professor Moore stated that two items stand out as major factors: (1) localized stresses and (2) repeated stresses. The computation of localized stresses in machine parts cannot as yet be made accurately. There are several mechanical solutions, however, for problems which cannot be solved by mathematics. Polarized light is being used to determine localized stresses and the soap film method has also been employed.

Failure under repeated stresses is qualitatively different from failure under static load. Some small defect or slippage of laminae gradually spreads under repeated stresses until failure results. "What shall we consider the safe limit of stresses under these conditions?" Professor Moore asked. "It must be," he said, "a little below that at which this spreading failure occurs." This limit is called the *endurance limit*. Below it we need not fear failure under any number of repetitions. For some wrought ferrous metals, free from defects, the ultimate tensile strength, as ordinarily found, is a good indication of the endurance limit. Under these conditions, it is about one-half of the tensile strength for stresses completely reversed. For cast-iron, cast steels, non-ferrous

metals, however, the ratio is lower. For most structural steels the endurance limit is usually higher than the yield-point if the stress is not reversed, and elastic failure is more to be feared than endurance failure, though the engineer must consider both.

Localized stresses, Professor Moore said, are an especially serious problem for the mechanical engineer. At the bottom of a thread of a screw, for example, the unit stress is not P/A but is about $4P/A$. The theory of elasticity upon which the ordinary treatment of mechanics of materials rests, contains some errors. While the theory of elasticity is "statistically true," it is only approximately true for localized stresses and is of no use at all for material considered atom by atom, because material is not homogeneous as we assume it to be, and the properties of a large piece of material are not the properties of an extremely small particle. We will always, Professor Moore said in conclusion, have with us the factor of safety.

The papers on factors of safety and endurance limits were followed by some discussion and questioning, in the course of which Professor Moore expressed the belief that in the future specifications for materials to resist repeated stress may be based on a new system in which endurance limits will be definitely specified.

Thursday, July 21. Afternoon Session

H. F. Moore: PLANNING AND CONDUCTING COURSES IN MATERIALS TESTING LABORATORY.

The session was devoted to a general discussion of courses in materials testing led by Professor Moore and participated in by the members.

To the question "What is the purpose of a materials testing laboratory?" four objectives were suggested:

1. For the study of the laws of mechanics of materials. This objective was said not to be a common one.

2. For the study of basic properties of common materials of construction. This is the objective most commonly followed, the assumption being that the laws of mechanics have

already been learned. The materials most often studied are brittle materials, including materials of masonry construction; timber; metals; and sometimes rubber.

3. For training in the technique of handling testing apparatus. This is rarely the objective, although it might be in elective courses for men who expect to become engineers of tests.

4. For secondary purposes, including, (*a*) the furnishing of contact between the college and industry; (*b*) developing in the student an appreciation of the proper degree of accuracy and sensitivity in experimental work; (*c*) the study of mechanical substitutes for mathematical analyses. This last is rarely the objective in undergraduate courses.

The question was immediately raised as to whether laboratory courses in materials testing could not serve more than one of the above purposes. Some laboratories, it was stated, are used entirely for the second purpose, whereas others are used to furnish explanations of the laws of mechanics as well as to study the properties of materials. While no count was taken, it seemed to be the general feeling that undergraduate courses in materials testing should serve both of these ends.

The discussion turned at this point to the question of whether laboratory courses should consist of a definite number of experiments which the student should be required to complete within the prescribed time, or of a definite number of clock hours spent in the laboratory during which the student may do more or fewer tests. It was found that nearly all of the laboratory courses with which the members were acquainted were arranged on the basis of a definite quota of work.

The writing of laboratory reports was then considered. Professor Moore believes that the report is the most important part of an experiment. If well done, the report will require as much time as will the test itself. He believes that a rather generous allowance of time should be given for preparing reports.

The question of the content of materials testing courses

received only passing mention, the discussion turning to the types of experiments. Professor Moore mentioned one test in which he uses a slab of rubber about 2 in. x 6 in. in cross-section and 3 feet long. Half-inch squares are marked on the surface of this slab with ink and it serves very satisfactorily for qualitative observations of strains due to different methods of loading.

The class versus the squad experiment was also discussed. Professor Withey stated that at Wisconsin certain of the preliminary experiments are conducted for the benefit of an entire class group, the number being limited by the space around the testing machines from which students can observe. Most of the tests, however, are conducted by squads of three or four men each.

Other features of the Wisconsin laboratory course were explained by Professor Withey, including the scheduling of tests and the content of the course. The relation between experimental work and classroom study of the theory was also discussed. The experience of certain of the members with courses arranged so that the student performs the laboratory experiments at about the same time he studies the principles in class were cited as indicating the fact that the two types of work supplement each other in a valuable way.

In concluding the discussion Professor Moore called attention to experiments which may be conducted with the use of a strain gauge and without the use of any testing machine. In his own class he has groups of students visit a railroad roundhouse and measure the stress in a turntable under load. Such tests, he said, have many possibilities and serve a number of useful purposes, among which are indications of the application of principles to full-sized members.

Following a recess the members assembled in the Materials Testing Laboratory and under the guidance of Professor Withey inspected the equipment and discussed numerous features of the installation. The beam-balance type of machine was described as the most consistent and accurate although

not as rapid as the self-indicating type. The hydraulic machine has certain advantages over the beam type, though it is not so often employed in this country. Arrangements to prevent injury to testing machines by students, such as a device to prevent loading beyond one-half of full capacity, were explained. There was also some discussion of the construction of home-made testing machinery such as the use of an hydraulic jack and pressure gauge for compression tests and an engine lathe for torsion tests. Professor Withey explained that such expedients are not recommended for general use.

Thursday, July 21. Evening Meeting

H. F. Moore: THE HISTORICAL DEVELOPMENT OF MECHANICS.

Professor Moore stated, in introducing his topic, that it is obviously impossible in a single lecture to do more than glimpse briefly certain of the outstanding figures in the history of the development of mechanics. He referred those who wish to study the history of mechanics in detail to Mach's *Science of Mechanics* and stated that much of the material he would present followed Mach quite closely.

Archimedes (287–212 B.C.) was the first outstanding figure in mechanics. To give an idea of the state of the art of mechanics in Archimedes' day, he quoted from Perrin's translation of Plutarch's *Lives*: "For the art of mechanics, now so celebrated and admired, was first originated by Eudoxus and Archytas, who embellished geometry with its subtleties, and gave to problems incapable of proof by word and diagram, a support derived from mechanical illustrations that were patent to the senses. . . . But Plato was incensed at this and inveighed against them as corrupters and destroyers of the pure excellence of geometry, which thus turned her back upon the incorporeal things of abstract thought and sense, making use, moreover, of objects which required much mean and manual labor. For this reason mechanics was made entirely distinct from geometry and being for a long time ignored by the philosophers, came to be regarded as one of the military arts."

Archimedes' chief contribution to the laws of mechanics was the demonstration of the law of the lever, a more complete statement of which will be found in Professor Rettger's lecture as printed in Part IV, which will appear in the March, 1928, issue of the JOURNAL OF ENGINEERING EDUCATION, and will also be found on pages 193 to 220 of Bulletin No. 14, *The Summer School for Engineering Teachers,* a separately bound volume which may be obtained from the Lancaster Press, Lancaster, Pennsylvania.

From Archimedes Professor Moore turned to Stevinus (1548–1620 A.D.) and gave an account of his development of the theory of the inclined plane which, he said, contained the germ of the idea of the parallelogram of forces, although it was some sixty-six years after Stevinus died that Newton, and independently Varignon, stated the parallelogram law as we now know it.

Galileo (1564–1642) was discussed next and a brief account of his life and his struggles against Aristotelean philosophy was given. Galileo was characterized as the prophet of experimental study who used the "mean and ignoble" method condemned by Plato and dared to appeal from reason to experiment. He gave us our concept of acceleration and the beginnings of a generalized idea of forces but he gave us no concept of mass.

Huygens (1629–1695) was next considered. His great work in mechanics was said to have been the development of the theory of work and energy of the particles of the compound pendulum. Huygen's method of developing the principle of the compound pendulum was described by Professor Moore and was said to contain the germ of the idea of the development of the mechanics of bodies from the mechanics of a particle.

Newton (1642–1726) was mentioned only briefly since a much more extended account of his life had been given by Dean Slichter. (Dean Slichter's address is printed in full in Part IV, which will appear in the March, 1928, issue of the JOURNAL OF ENGINEERING EDUCATION, and will also be found on pages 230 to 249 inclusive of Bulletin No. 14, *The Summer*

School for Engineering Teachers, a separately bound volume which may be obtained from the Lancaster Press, Lancaster, Pennsylvania.)

Hooke (1635–1703), whose great work was the *Micrographia,* contributed to the laws of mechanics and to the mechanics of materials, Professor Moore said, and it is by his name that we still know the elementary law of elasticity. His work was purely experimental and in sharp contrast to other derivations of laws which were, in part at least, analytical. Hooke, Professor Moore said, almost developed the flexure formula. In the field of theory he is the man who *almost* developed principles.

Turning from pure mechanics to mechanics of materials, Professor Moore traced the development of some of its more important principles. In the early days, he said, mechanics of materials was entirely an art, rather than a science, and according to Greek ideals to be considered "degraded" in comparison with philosophy. Tension and compression, he said, have always been instinctively grasped, whereas flexure and torsion puzzled the ancients. Galileo made the first recorded attempt to develop the flexure formula on the assumptions: (1) that material is rigidly inextensible; (2) that stresses are uniformly distributed; and (3) that there is a pivot at the concave edge of a beam. For rectangular beams these assumptions lead to an equation which gives stresses one-third those of the present-day formula, but since the stresses are made to vary inversely as the square of the depth of the section, give useful results for rectangular beams if suitable coefficients are introduced.

In the period from Galileo's day until 1824, Professor Moore said, the formula for beams gradually took shape, with much accompanying speculative reasoning concerning the continuity of solids. Hooke's law showed that Galileo's first postulate was in error, then followed the recognition of both tension and compression in beams, then came Bernoulli's assumption, and finally a long discussion of the neutral axis.

Prominent in the development of the mechanics of materials were Navier (1785–1836) and St. Venant (1797–1886). Na-

vier, Professor Moore said, began the work which was continued later by St. Venant. He gave us the correct theory together with the equations for the deflections of beams substantially as they are used today, but his work is encumbered with much speculation about the nature of the structure of matter. St. Venant is perhaps the most prominent figure in the development of the mathematical theory of elasticity which recognizes that there is deformation at right angles to applied loads. He may be characterized as a mathematician with a keen sympathy for the problems of the practical structural engineer.

Rankine (1820–1872) was the last of the important figures in the history of mechanics to be considered by Professor Moore. His *Applied Mechanics*, published in 1858, was the first text in which "the equilibrium of stress at a point in a solid mass and the general theory of elasticity were brought within the scope of a student's course and within the reach of the engineer's drafting board." Rankine may be characterized, Professor Moore said, as an engineer who had a sympathetic understanding of the viewpoint of the mathematical elastician.

Professor Moore concluded his address by consideration of the question "Are the basic assumptions of mechanics of materials true?" These assumptions, he said, are: homogeneity and indefinite divisibility, isotropy, and Hooke's law. Early discussion centered around atomic theory. This is recognized to-day, he said, and invalidates the first assumption; so also does the work of the microscopist, who shows us plainly that the ordinary materials of engineering are not homogeneous and not indefinitely divisible. Hooke's law may be regarded as empirical; very closely true within fairly clearly marked limits. "If," he said, "we wish to be dramatic, we may say that the whole theory of elasticity is founded on two false postulates and one approximation. It would be fairer, however, to say that the theory of elasticity may be regarded as statistically true for actual material, and where it fails in exactness, has been found to give results which err on the safe side."

In recent years when the study of localized stress has become of importance, the limits of the theory of elasticity are beginning to become correspondingly important. The theory must, therefore, be used with discretion and not worshipped.

Finally, "how shall the engineer view his science of mechanics?" he asked. The general laws of mechanics—Newton's laws—may be regarded as exact for all present-day problems in terrestrial mechanics, but they should not be worshipped as laws eternally fixed and completely stated.

The laws of mechanics of materials are a good working hypothesis which serve us well but they are not exact laws for terrestrial solids, and they are by no means to be worshipped. They are useful, safe and the best we have.

Friday, July 22. Morning and Afternoon Sessions

M. O. Withey and H. F. Moore: MATERIALS TESTING LABORATORY DEMONSTRATIONS.

The entire day was devoted to demonstrations of materials testing laboratory experiments. Half of the group reported in the morning and the other half in the afternoon. Those not in attendance at the laboratories took occasion to visit the other laboratories of the Engineering College. The first experiment conducted was a tensile test of steel using a dial type of extensometer. Various observations taken by students and the procedure of the instructor in supervising the conduct of the test, including such matters as the checking of the set-up of machine and instruments to see that everything is in readiness for the test, were explained in detail as was also the actual conduct of the experiments.

The second experiment was the bending test of a wooden beam using a deflectometer to determine the deflection. The various supplementary measurements, such as the determination of the density of the wood, the number of annual rings, percentage of summer wood, and the like, were explained, as well as methods of having the students estimate visually the properties of the wood before making the test. This test, it was explained, is used to acquaint students with the principles of grading lumber.

The third experiment shown was the impact tension test. A number of specimens were broken to indicate the different degrees of toughness in specimens of structural steel. In this test the effect of the form of the test specimen on strength was indicated.

The session concluded with statements by Professor Withey as to procedures followed in his courses in the preparation and submission of reports.

Saturday, July 23. Morning Session

H. F. Moore: CONDUCT OF MATERIALS LABORATORY CLASSES.

The meeting took the form of a general discussion, led by Professor Moore, and participated in by all of the members of the conference, of methods of conducting laboratory courses in materials testing. Each of the most important features of such courses was brought up for discussion, and opinions upon them were expressed freely. No attempt was made to arrive at a consensus of opinion on these points but they were all discussed at sufficient length to show either the general trend of opinion or the chief points of divergence. The discussion was too extended for inclusion herein, and it was not such that a satisfactory digest can be presented. The following topics constituted the basis of discussion: selection of laboratory instructors and assistants and qualifications they should possess; the extent to which students should participate in the actual conduct of the testing work, including how much of the assembling of equipment and specimens and the setting up of apparatus they should be required to do for themselves; accidents to machines and injuries to students which are likely or possible, and means of prevention; use of manuals or handbooks of laboratory courses and uses thereof, also methods of duplicating laboratory instructions for distribution to classes; devising of forms for recording data and extent to which students should be required to devise their own forms; instruction of students in the recording of data neatly and quickly; organization of laboratory squads, appointment of leader, and designation of students for particular parts of the tests; oral explanations of laboratory experi-

ments as a supplement to written instructions; submission and grading of reports; punctuality; correction of reports for English and spelling; time required for report writing; preparation of sketches and diagrams and use of duplicated sketches and diagrams in this connection; methods of drawing curves; and interpretation of results of tests.

Monday, July 25. Morning Session

At the beginning of the session Professor Woodward presented a proposal to form a permanent organization of the members of the conference for the purpose of keeping the members in touch with one another and to take the initiative in arranging for further conferences on mechanics. The proposal was approved by the members and the Advisory Committee of the Staff was instructed to appoint an executive committee of seven members to report upon the details of the organization. The meeting then turned to the regular item of the program.

F. E. Turneaure: STRUCTURAL MECHANICS.

Bridge analysis does not seem difficult, Dean Turneaure said in opening his remarks, yet there are many conditions, especially in connection with live loads, that seem to require a course of considerable length. He proposed to deal with some of these conditions in a broad way; not to give a detailed analysis of any particular problem of structural design. Analytical, rather than graphical, analysis forms the basis of structural mechanics, he said, the latter not being used to any great extent except in the design of roof trusses and arches.

Considering first what may be termed the orientation of the student to structural mechanics, *i.e.*, the creation of a perspective or background against which he should consider its problems, Dean Turneaure said that the first consideration is to impress upon him that almost all problems are considerably simplified. We assume, for example, that all members are hinged; that the weight of a member is transferred to the joints; that we can deal with only one truss at a time—that other parts of the structure have no influence on it; that live load is carried to the trusses by floorbeams acting as simple

beams; that reaction at one end of a truss is vertical; that the effect of deformation on general dimensions of a structure can be neglected.

Turning to the general methods of analysis pursued in structural mechanics, Dean Turneaure said that the free body method is generally employed. The various joints of a truss are considered separately and a vector diagram drawn for each of them. The principle that the sum of the horizontal components and the sum of the vertical components of all forces must equal zero is then applied. The problem is eighty per cent solved when the sketches are complete and the equations of equilibrium correctly set up. Too much emphasis cannot be placed upon the importance of defining the problem and setting up the equations; it is the most important part of the entire process.

Trusses are considered to act as beams, Dean Turneaure said, and the general effects of the loads upon them may be divided into bending moments and shears. Both fixed and moving loads must be considered, the effect of the loads being such that both plus and minus shear may occur in certain portions of the truss. Moment controls the chord stresses and shear largely controls stresses in web members, and the effects of different positions and arrangements of the loads are studied from the standpoint of their effect on moment and shear. The two are quite different and a treatment of trusses from this point of view is of great importance. In determining the positions in which loads should be placed to give maximum moment and shear, influence lines are used.

Considering the nature of loads which structures must bear, Dean Turneaure said that live loads introduce the complication of impact, or dynamic effect. The term impact is not a good one, he said, because the effect of speed is not the same as the effect of a blow. The greatest effect is caused by unbalanced counterweights on the driving wheels of locomotives. Centrifugal force causes varying pressures on the rails which may range from zero to twice the corresponding static load. This effect is important and must be taken into account. It is greatest when the rate of variation of the impulse on the

rails synchronizes with the natural period of vibration of the span.

Passing on to other matters, Dean Turneaure mentioned again that the practice is to simplify a great deal when trusses are considered as though they were separate structures. In some cases, however, this simplification does not apply to the problem under consideration. The portal of a skew bridge, for example, is a problem in three dimensions and the determination of the stresses around the corners involves applications of the principles of solid geometry. Again, he said, if a bridge abutment settles under one corner of the span, how may the stresses which result from this action be determined? The determination of the stresses in the supports of an elevated water tank due to wind action furnishes another illustration of a problem which cannot be solved in two dimensions.

In certain problems, especially in the design of details, Dean Turneaure said, the engineer should develop the ability to judge stresses from distortions. For example, the stresses in an angle caused by tension are affected by whether or not bending can occur. The way in which the angle is fastened at the end to other parts of the structure will often indicate whether bending can or can not occur and, therefore, what stresses may be expected in the member.

Certain errors in design and in procedures of analysis were pointed out. It is customary, for example, to consider only stresses on horizontal planes in high masonry dams. As a matter of fact, however, the stresses on an inclined plane may be much greater. Failure to consider stresses on such planes has led to some bad designs as shown, for example, by the cutting back of the toe of a dam, when it would have been better to run it down into the bedrock so that the stress could be transferred to the rock.

Following Dean Turneaure's remarks, W. S. Kinne, Professor of Structural Engineering in the University of Wisconsin, discussed the principles of mechanics that are used in his courses. Particular attention was paid to the use of equilibrium equations for concurrent and non-concurrent forces, the changing of a force into a force and a couple, and the draw-

ing of sketches. His remarks were followed by general discussion on the subject matter of the two preceding addresses.

A question was raised as to the extent of the review of fundamentals of statics which students must be given in in courses in structures. Professor Kinne pointed out that a good deal of such drill is necessary in order that the students may handle with facility principles learned in mechanics. Other questions related to certain technical aspects of analysis and design touched upon by Dean Turneaure and Professor Kinne.

Monday, July 25. Afternoon Session

O. A. Leutwiler: Applications of Mechanics to Machine Design.

In order to indicate the applications of mechanics which are made in machine design and to show the methods of procedure employed in designing machines, Professor Leutwiler first mentioned the three major steps to be taken: (1) consideration of the motions that will be involved; (2) consideration of the forces acting upon each element of the machine; (3) consideration of the stresses set up in each element and of the proportioning of the elements. The second of these steps, he said, is pure mechanics. The third step involves a knowledge of the strength of materials.

In order to give an idea of the extent of knowledge of analytical mechanics that should be at the command of a machine designer, Professor Leutwiler considered the case of a six-cylinder automobile engine and outlined the various steps involved in determining the forces produced in the engine. A condensed statement of his remarks follows.

When this problem is assigned to a student, the first step is to lay out a probable indicator diagram of pressures in the cylinder, constructed on a stroke-line base, from which the net pressure on the piston is determined. The next step is to calculate, or determine graphically, the acceleration of the piston and its inertia force. The effect of the connecting rod is determined by substituting for the rod a kinetically equivalent system made of two masses A and B joined by a weight-

less rod. By means of graphics, the accelerations of A and B can be found, and from these the inertia forces may be calculated. From the foregoing it is possible to determine the resultant force at the wristpin, the side thrust exerted upon the cylinder walls, and the force transmitted through the connecting rod. The last named force may be resolved into a radial and a tangential component, the latter being the turning effort. The combined effect of all six cylinders is then plotted on a base line representing the developed crank circle, the area under the curve denoting the work performed. From this diagram it is possible to determine the weight of the flywheel needed.

Shaking forces are next considered. Those which cause vibration in an engine are the inertia forces of the piston, the rod, and the crank and crank pin. The resultant of the three forces, obtained by means of a force polygon, represents the total shaking force. The shaking-force diagram for a single cylinder is usually laid out on the crank circle as a base line, the center of the circle being used as a pole. The mean shaking-force circle is determined and this gives a means of arriving at the proper amount of counterbalance to be used.

This problem, Professor Leutwiler said, requires the application of a large number of principles of mechanics and he considers it the best problem that he knows from that standpoint.

The lecture was concluded by a brief discussion of Coriolis' law which applies to the acceleration of a body moving in a path which itself rotates about a fixed point. This law is useful in the design of governors, centrifugal pumps, and fans or blowers. Problems in the application of the law are given both in analytic mechanics and in the design of machines.

Tuesday, July 26. Morning Session

In accordance with the action of the group looking to the formation of a permanent organization of its members taken at the morning session of July 25, Professor Woodward presented a set of resolutions which are reproduced here in their adopted form.

Resolution

Be it Resolved: That it is the conviction of those in attendance at the 1927 Wisconsin Session of teachers of engineering mechanics, that the magnificent success of the experimental undertaking this year not only justifies this experiment, but demonstrates the need for such conferences, and indicates the desirability of holding another similar conference in this same field during another year in the early future.

While we recognize the impossibility of settling at this time the details of the arrangements for any future similar gathering we desire to express opinions on some points as follows:

1. It is highly desirable that the next session be held in conjunction with a regular meeting of the S. P. E. E.

2. The sessions of the conference should be so arranged in cooperation with the summer school of the institution where it is held, as to make it as convenient as possible for attendants at the conferences to take also summer courses for credit.

3. Attendance should be restricted to those who already hold baccalaureate degrees, or who are experienced teachers in engineering institutions.

4. Besides the provision of meetings for the discussion of teaching and other educational questions, there should be provided definite content courses as follows:

A. An intensive review of the fundamentals of analytic mechanics covering statics and dynamics.

B. An advanced course in mechanics.

C. Mechanics of materials.

D. Additional courses in the allied subjects touched upon at this conference, such as hydraulics, structural design, machine design, theory of electricity, etc., in accordance with the demand that may be found to exist.

5. The conference should not be less than two weeks and not more than six weeks in length.

6. The next Conference on Mechanics should be held preferably in 1930.

7. In order to provide a permanent skeleton organization for fostering future interest in this field, and to be a permanent agency for keeping those in attendance at this meeting in touch with each other, and possibly to be a central agency or clearing house for helping the various members to collect data and conduct investigations on teaching questions raised at this conference, and to cooperate generally with the standing committee of the S. P. E. E. on mechanics, and to be a permanent repre-

sentative of those in attendance at this session, a permanent executive committee of seven should be chosen. This committee should have the authority to change its size and to fill vacancies as the need may arise in the future.

The resolutions were received favorably and the discussion was concerned chiefly with the details of the plan. It was felt that six members of the committee should be chosen at once, and the President of the Society requested to name the seventh member, the expectation being that Professor A. P. Poorman, Chairman of the Society's Standing Committee on Mechanics, would be oppointed. Professor Woodward asked for a show of hands upon various matters with which the resolutions are concerned with the following results:

19 favor holding the next session of this conference in connection with a regular meeting of the S. P. E. E.;

10 would attend if the work were arranged so that they could also take summer courses for credit;

10 would be interested in having as parts of the program definite courses giving a review of the fundamentals of statics and dynamics;

15 would be interested in courses in advanced mechanics;

15 would be interested in courses in mechanics of materials;

22 favor a session of two weeks, 3 a session of three weeks and 12 a session of six weeks;

12 favor beginning the conference about June 15, 8 about July 5, and 3 favor a later date;

9 favor another conference on mechanics next year, 6 prefer two years from now and 14 favor a later date.

O. A. Leutwiler: APPLICATIONS OF MECHANICS TO MACHINE DESIGN.

Professor Leutwiler's lecture was a continuation of his remarks of the previous day. "There is at present," he as-

serted, "a definite trend away from cut-and-try methods in the direction of the application of mathematical analysis." This is especially true in the design of steam turbines, internal combustion motors, airplane engines and high pressure vessels. In many such cases the customary application of the principles of mechanics of materials is not sufficient and as a result the theory of elasticity must be used. Many failures of machine parts can be traced to localized stresses that cannot be adequately dealt with by theoretical analysis and hence experimental methods of studying stress distribution are also being developed. The photo-elastic method of determining stresses is a good example of this development.

From this introduction Professor Leutwiler proceeded to discuss in detail a number of special cases which arise in machine design. These are noted below in a brief summary of his remarks.

(1) *Localized Stresses.*—An ordinary bolt subjected to axial pull was considered, and the effect of the absence of a suitable fillet to connect the body of the bolt with the head was shown to cause a high concentration of stresses at that point. Similar analysis was made of the stresses at the root of the thread. It was also shown that a small hole drilled through a thin bar produces a high localized stress, and in the case of a bar with a semicircular notch it was shown that the maximum stress concentration is approximately twice the average stress intensity.

(2) *Beams.*—For all ordinary problems the common flexure formula is suitable. It must be remembered, however, that there is a more complicated stress distribution in the vicinity of the point of application of the load and that in certain cases a more extended analysis of stress is required. The actual variation of the shearing stresses in a beam also assumes importance in the cases of special forms of cross-sections.

(3) *Shafting.*—Most shafting used in machinery is subject to a combination of bending and torsion and recent practice employs the theory of maximum shear in designing shafts.

Stresses in shafts are also complicated by keyways which produce high localized stresses.

(4) *Cylinders.*—The stresses set up in bumped heads are very difficult to determine and at present empirical formulas are used extensively. Modern methods of welding are also changing the methods of designing pressure vessels and high pressures accompanied by high temperatures call for still further methods of analysis.

(5) *Curved Beams.*—These are used considerably in machinery, as, for example, crane hooks, frames for punching, shearing and riveting machines, and the like. The ordinary flexure formula as applied to straight beams may give stresses that are much too small. The curved beam formula is more complicated but is coming into rather general use.

(6) *Friction Clutches and Brakes.*—Experimental methods are now used extensively and the laws of friction as applied to clutch and brake design require considerably more study than has been given to them.

(7) *Welded Joints.*—Great interest is now being shown in electrical welding and all kinds of machine parts are being made at less cost by this process than by other methods. This calls for a new study of the strength of joints.

(8) *Repeated Loads.*—The study of endurance limits is receiving considerable attention and values of that quantity are now being established by experimental methods.

(9) *Rotating Disks.*—Analysis of high speed shafting and flywheels is beyond the reach of the ordinary courses in strength of materials and also of most courses in machine design. Nevertheless designers of machines are required to deal with them.

After discussing these developments in the application of the principles of mechanics to machine design, Professor Leutwiler outlined the course in machine design pursued by students at the University of Illinois. Each student is required to design a small air-riveter in the junior year and a punching and shearing machine in the senior year. The men work in groups of four, which are further subdivided into two

groups of two students each. Leaders are chosen for each group. The problem is stated in the form of a specification. Three hours are allowed for the study of the specifications and the preparation of a sketch of the proposed machine. This sketch is reviewed by the instructor. Three hours more are spent in developing the method of procedure. This is reviewed by the teaching staff and discussed by the entire class. The students then draw up a standard method of procedure to be followed by all. Each group reports to the instructor once each week to have both the theory and the numerical computations checked. At the end of the semester each man submits a report. The average student takes about forty-two hours to make the computations on each machine. A detailed schedule is posted on the bulletin board so that the students can check their progress. The drawing of the design takes most students about fifteen hours. The fast men are dismissed when they complete the design whereas the slow men find it necessary to work overtime. Considerable range in the speed of the students is observed.

Tuesday, July 26. Afternoon Session

Edward Bennett: THE RÔLE OF MECHANICS IN ELECTRICAL ENGINEERING CURRICULA.

Professor Bennett explained the fundamental importance of the principles of mechanics in electrical engineering, developing the relationships between the various electrical units and exhibiting several pieces of apparatus used in measuring certain fundamental units for the purpose of establishing a starting point in the electrical system. A condensed version of Professor Bennett's remarks follows:

There are two distinct respects in which mechanics is to be rated as one of the fundamental subjects in a course of study for the work of electrical engineering.

The first is this: Of the technical problems which confront the practicing electrical engineer, for every problem which requires for its solution a knowledge of electrical theory, there are two or more equally important problems which require for

their solution an application of the principles of mechanics and a knowledge of the properties of materials.

The second and even more important respect in which mechanics is of such fundamental significance in the electrical engineering course is that electrical theory is a structure which is built upon the fundamental concepts developed in mechanics. In the development of electrical theory, as the development is presented to students, it is assumed that such terms as frames of reference for specifying position, time-intervals, velocity, acceleration, mass, and force have been adequately defined in mechanics, and the procedure is to define the entire range of electrical quantities in terms of these concepts and quantities.

This address deals only with the rôle of mechanics as the foundation upon which the superstructure of electrical theory is built. Its purpose is:

To present a survey or sketch of the manner and sequence in which all electrical quantities are defined and measured in terms of length, time, force and work;

To exhibit and to describe the method of using the equipment which has been developed for use in those experiments in which the student starts with the definition of any electrical quantity such as difference of potential, current, or magnetic flux density, and then by a method which involves nothing but the use of a rule, a balance, and a time-keeper, calibrates an instrument for measuring the quantity in question.

It is hoped that two things will stand out clearly:

First. That the electrical quantities are defined in an *unbroken sequence,* the definition of each new quantity being in terms of one, or at the most two, of the previously defined electrical quantities and of the quantities of mechanics, mainly, length, force and time.

Second. That all the electrical concepts have been devised for the purpose of rendering a simple account of observed motions and deformations and that the fundamental meaning of the electrical quantities is to be sought in the measuring operations with scale, balance and time-keeper which must be

carried out in order to assign a numerical value to the quantity.

The speaker then defined the more important electrical quantities in unbroken sequence, and, after many of the definitions, exhibited and explained the equipment by which the quantity might be measured by an absolute method. The definitions were presented in the sequence followed in *Introductory Electrodynamics for Engineers* by Bennett & Crothers. This text may be consulted for the definitions and for a description of some of the experimental equipment.

S. M. Woodward: AN APPLICATION OF THE THEORY OF MECHANICS TO HYDRAULICS.

Professor Woodward demonstrated the flow of water from a small sharp-edged orifice, using the facilities of the hydraulic laboratory for that purpose. He then developed analytically a method of determining the coefficient of discharge from the orifice based upon the principles of pure mechanics, verifying the results by the observations of the coefficients previously obtained experimentally. The results of the two procedures checked very closely.

The hydraulic jump was also demonstrated as a preliminary to Professor Woodward's lecture scheduled for the afternoon of July 27.

After Professor Woodward's demonstration the members were conducted through the laboratory, and its various features were explained by Mr. L. H. Kessler, a member of the staff of Hydraulic and Sanitary Engineering of the University of Wisconsin.

Tuesday, July 26. Evening Meeting

C. K. Leith: MINERAL RESOURCES—SOME OF THEIR POLITICAL ASPECTS.

Dr. Leith took as his theme the exploitation, or development, of the mineral resources of the less advanced nations, the international complications which may be caused, and the policies which may be adopted to avoid undesirable results.

Because of modern industry's steady, relentless demand for raw materials, and because of the organization of our civilization along national lines, exploitation of natural resources of backward countries cannot be avoided, he said. The practical problem of international relations is simply to see that the necessary exploitation is done decently and with some regard for the rights of other nations. Dr. Leith used the term "exploitation," he said, not with the too frequent connotation of imperialistic pillage but in its primary sense of development. He pointed out that the mineral resources of Mexico and Nicaragua are certain to be exploited, that is developed, by American capital but maintained that it is possible to conduct the exploitation in such a manner as to be fair to both sides and to eliminate much unnecessary friction.

"At present," he commented, "the American public is much confused. Part of it, following the lead of statements of our government, ignores the fact of exploitation or even believes it does not exist; another part wastes its time thinking about useless schemes of stopping exploitation, entirely on the assumption that exploitation is inherently wrong; while still another recognizes exploitation, but thinks it must be well done, because conducted by Americans.

"None of these points of view starts with the inevitability of exploitation and the natural right of the world to it, and confines its attention to abuses in the method. We owe not only support to our own nationals doing the work, but to weaker governments trying to resist excessive and unfair pressure from them."

Dr. Leith developed the idea introduced by these comments and discussed a number of aspects of the effects of the development of mineral resources in various parts of the world.

Wednesday, July 27. Morning Session

Announcement was made of the following appointments to the committee created for the purpose of arranging for further conferences on the teaching of mechanics:

S. M. Woodward, *Chairman*,
D. M. Bavly,
S. B. Folk,
E. R. Maurer,
M. K. Snyder,
LeRoy Tucker,
A. P. Poorman.*

Edward Bennett: A New Approach to the Study of Mechanics.

Professor Bennett prefaced his remarks by saying that some time ago he had prepared a compilation of the fundamental laws and definitions of electrodynamics which was designed to distinguish between the four types of relations which are dealt with in physical science, namely: (1) relations which have been determined purely by observation and *experiment;* (2) relations which are matters of *definition* or convention; (3) relations which have been *deduced* from fundamental experimental relations for the values of newly defined quantities; and (4) relations which are *generalizations* based upon very extended experience.

The preparation of this compilation, and the conviction that much confused thinking may be attributed to failure to distinguish between the relations given above, had led him, he said, to attempt to prepare a similar compilation of the fundamental laws and definitions of mechanics.

As a further introduction to his remarks, Professor Bennett continued: "You will recall that many of the quantities discussed yesterday were defined in terms of force, not an obscure electric force, but the force on bodies as measured by ordinary mechanical methods. You will also recall that the statement was made that we are not thinking in terms of fundamental matters of observation when we think in terms of force. Moreover, it is recognized that electrical and optical experiments show that time-intervals and space-intervals are not the inde-

* Subsequently appointed by President R. L. Sackett in accordance with the action taken on July 26, 1927.

pendent unrelated quantities they are assumed to be in Newtonian mechanics. In other words, present concepts of mechanics are inadequate as the foundation for a comprehensive electrical theory." Professor Bennett stated his belief that a new approach to the principles of mechanics is of fundamental importance to students of electrical engineering and that it was this belief that led him to present the compilation of the laws of mechanics which he desired to discuss.

"It may throw some light on the features of this compilation," he said, "if I read the following somewhat disconnected paragraphs selected from the observations which I jotted down while formulating the plan of the compilation.

" 'The thesis which the compilation should sustain may well be this: The problem of mechanics, or of physical science in general, is to devise the simplest and most comprehensive account of observed motions and deformations, or of *change* (or non-uniformity) as contrasted with sameness.

" 'The source of much confusion is that to account for *change,* we talk of forces, atoms, electricity, electrons, strains in a medium, etc., but the definitions of these quantities in terms of primary observations become so round-about and involved that we cannot visualize the relations as a whole.

" 'Stating the same thought in other terms: Gravitational forces, fluids, electricities, aethers, atoms, electrons, etc., are all concepts which have been devised or evolved in the attempt to correlate the infinite complex of observed change. Numerical values are assigned to all these things, and the basis for the assignment of numbers is measurement, and the basis of all measurement is change, for example, shifting the measuring rod. It behooves us, then, to define, or to think of, all quantities in terms of change in the most direct manner possible. The intervention of the concepts of space and time, particularly the latter, in the definitions of many quantities such as velocity, acceleration, force, etc., is the source of much confusion.

" 'I hope to describe all *involved* changes in terms of two or more elementary types of change which are selected as stand-

ards of comparison. I do not think for a moment that such a procedure will enable us to dispense with the concept of atoms, electrons, etc. But I should hope to define these concepts in a more direct way in terms of *change*.

" 'In a fundamental study of phenomena, a watch or a clock should not be thought of as a 'time-keeper,' but as a 'repetitional mover,' or as a 'standard of cyclic motion.' This implies that we regard the time concept as an unnecessary and extraneous concept, introduced as a brief or short-hand way of comparing the motion with the standard of cyclic motion (the day and night cycle, the pulse cycle, the pendulum cycle). This 'time' concept is probably to be put in the class with many other symbolic methods of describing relations, a very useful invention as long as the definition of time was kept prominently in the foreground, but leading to perverted and pernicious views after the origin of the term had become obscure. It may be, that Newton's conception of 'absolute, true, and mathematical time, of itself, and from its own nature, flowing uniformly on without regard to anything external,' is the supreme example of the idolatrous tendency of mankind.' "

Following these introductory remarks attention was directed to the features of the Compilation of Fundamental Laws and Definitions which had been distributed.

This compilation will ultimately appear as a bulletin of the University of Wisconsin. The laws and definitions are arranged under the divisions shown in the following tabulation:

A Compilation of the Fundamental Laws and Definitions of Mechanics and Electrodynamics

Mechanics

I. The raw material of physical science.
II. Relations pertaining to counting and to numerical operations.
III. Geometrical relations: Relations pertaining to the shapes of objects which are substantially stationary relative to the observer. The space mode of arranging objects.
a. Rigid bodies.

b. The line and its elementary parts, or segments.
c. Surface and its elementary parts.
d. Volume and its elementary parts.

IV. Kinematical Relations: Relations used in describing motion in terms of standards of motion. The time mode of arranging events.
a. Relations pertaining to simple types of motion.

V. Dynamics: Relations pertaining to the circumstances attending the motions of bodies relative to a frame of reference.
a. Experimental basis of the Galilean-Huygenian-Newtonian conception that accelerations are to be regarded as the *direct* effects of the circumstances which determine motion.
b. Laws of motion and definitions of mass and of force.
c. Relations pertaining to the configurations and deformations which are determinative of forces.

VI. Principles of Relativity: Relations used in translating measurements made in a frame of reference F to a frame of reference F′ which is moving with a uniform velocity relative to F.

ELECTRODYNAMICS

VII. Electrostatic Relations: Relations pertaining to phenomena in which the statistical mean velocity of the electric ions is zero.

VIII. Relations pertaining to the phenomena in electric conductors.

IX. Relations pertaining to electromagnetic phenomena.

"In many respects," Professor Bennett said, "the situation to-day in the teaching of mechanics must resemble that which existed for several generations after Copernicus advanced the heliocentric theory.

"Just as the geocentric view continued to be taught for generations after the simpler and more comprehensive interpretation of Copernicus had been advanced, so the Newtonian mechanics which is taught to the engineering students of the present day contains not the slightest trace of the clearer and more comprehensive interpretations of Mach, Pearson, and Einstein.

"We are inclined to justify our practice of continuing to lead our students to lay an inadequate and faulty foundation

for thinking about physical phenomena by stating that for most purposes the Newtonian mechanics is a marvelously exact working system, and by raising the question as to what difference the concepts of Einstein will make in the practice of engineering. But it should be borne in mind that the Ptolemaic system of astronomy was a fairly precise working system, and that although the more adequate system of Copernicus may for a century have had little influence on the every-day practices of life, yet the Newtonian achievements were not possible until the Copernican views had become the property of school boys.

"And so it would seem that of all the opportunities confronting engineering teachers, none is fraught with the possibility of more revolutionary and far-reaching effects on engineering practice than is the opportunity to develop introductory mechanics in such a manner that the concepts and results of the theory of relativity will (for the coming generation of students) be divested of every trace of paradox.

"We may have every confidence that such a development is possible and that the acquirement of the new concepts will be no more difficult for the coming generation than was the acquirement of the Newtonian mechanics by the generation which is passing from the stage."

S. M. Woodward: MECHANICS OF THE HYDRAULIC JUMP.

The hydraulic jump, which had been demonstrated previously in the hydraulic laboratory, was discussed by Professor Woodward, who offered it as an example of the practical application of the principles of mechanics to an engineering problem which has received practical consideration comparatively recently. The use of the jump in the works of the Miami Conservancy District for the purpose of dissipating the energy of water flowing through the outlet tunnels of the retarding dams in time of flood seems to have been the first deliberate practical application of the idea, although the phenomenon has been studied for at least one hundred years. The jump is now being employed to dissipate

the energy at the toe of overflow dams so as to avoid scour. A feature of interest to teachers and students of mechanics is that the jump, in its simpler forms, obeys exactly the fundamental laws of mechanics; experimental results show no need for the introduction of empirical coefficients to bring them into harmony with the results predicted from mathematical theory.

The theory of the hydraulic jump was briefly explained and was followed by some questioning as to details of the equations. The applause with which the lecture concluded indicated the lively interest of the members in an application of the principles of mechanics in a field new to most of those present.

Wednesday, July 27. Afternoon Session

Stephan Timoshenko: PROBLEMS OF ELASTICITY IN MECHANICAL DESIGN.

Dr. Timoshenko's lecture was the same as the one presented at the Cornell session of the Summer School. A condensed account of the lecture is given in Part II, Proceedings of the Cornell Session, and will be found on pages 425 to 428 inclusive of the January, 1928, issue of the JOURNAL OF ENGINEERING EDUCATION and on pages 64 to 67 inclusive of Bulletin No. 14, *The Summer School for Engineering Teachers,* a separately bound volume which may be obtained from the Lancaster Press, Lancaster, Pennsylvania.

Thursday, July 28. Morning Session

It was announced that the sessions of the school would be brought to a close with the evening meeting of this day, in order to meet the desires of certain of the members to reach their homes by the end of the week. Action upon the committee reports, scheduled for the morning of Friday, July 29, would therefore be advanced to the afternoon session of the twenty-eighth.

C. S. Slichter: ADVANCED DYNAMICS.

"I will begin with a little propaganda," Dean Slichter said in introducing his remarks. "In my opinion, which is based

upon much experience in hiring and using engineering students and graduates, about forty per cent of engineering graduates would profit greatly by an additional year of college work immediately after graduation. Of the forty per cent, about one-half should spend part of the additional time in mechanics, particularly in dynamics. The first semester should be spent on the dynamics of rigid bodies, and the second semester on the dynamics of deformable bodies. They should get a large and fundamental point of view and appreciate the spirit of general dynamics. The great lack in engineering graduates is inability to visualize what is going on in a rigid or elastic body that has a part to play in the motions of a machine."

Following this introduction, the speaker outlined briefly the history of the development of rigid bodies by Euler and the men who came after him, illustrating certain points with mechanical models. Dean Slichter's remarks were such that a condensed summary, such as would be possible in the space available, does not give a satisfactory picture of their content.

Stephan Timoshenko: ENGINEERING EDUCATION IN RUSSIA.

Something of the status of engineering education in Russia was explained by Dr. Timoshenko who was, at one time, a teacher in the University of Petrograd. Russian engineering schools are among the oldest in the world and Dr. Timoshenko is a graduate of a school of engineering that is now one hundred and twenty years old.

Instead of higher technical education being supplied to meet the demands of industry, as is the case in this country, technical education in Russia until the time of the revolution of 1917 was under the auspices of a centralized government that had great political and economic power. As a result, work at the technical schools has not had very much influence on industry, though the schools have done much to promote high class work in science. The theory of long columns, for example, was developed by Euler (a Swiss) in Russia and was published there. Similarly the theory of continuous beams, many theories of elasticity and of shearing stresses

(the latter work by Touravsky, a Russian) were all developed in Russia, as was the theory of curved bars by Colovin.

College and university work in Russia before the revolution was on a rigid system, Dr. Timoshenko said, and students were obliged to attend all classes and lectures. After the revolution the German system was adopted. Attendance was not compulsory and the students simply presented themselves for examination. Since the introduction of this plan the lecture system has become a failure. Students seldom attend the lectures except just enough to keep the courses alive. If, at any time, there is no audience for a lecture, the professor declares the course abandoned for the semester, which means that no examinations will be given. As long as there is a single student, however, the lectures are continued, and the students therefore see to it that someone—it may be a student from another course—is present at every lecture.

Students do, however, regularly attend the periods that are assigned for problem and laboratory work. These are conducted by instructors who are engineers.

Before the revolution, engineering courses were of five years' duration. They are now nominally of four years. Actually, however, the average time needed for graduation has increased to seven years. Several factors contribute to this situation; for one thing, the Soviet Government requires the colleges to admit any child of communistic parents, regardless of preparation. For a long time, the children of educated people were absolutely barred from college attendance. These and other causes have made it necessary to modify methods of teaching radically and to do a great deal of elementary work. Under the old conditions the students came to college well enough equipped in mathematics to begin the study of mechanics in the first semester after admission.

Dr. Timoshenko believes that the Russian system is not the best for the average student although it is a good system for the good student. The American system seems to fit average conditions better, but an effort should be made to

develop more advanced courses in mechanics. American industry needs research engineers having extended training in mechanics.

Turning from the subject of education in Russia, Dr. Timoshenko touched briefly on the needs of industry for highly trained research and design engineers. He finds that industry has much difficulty in obtaining engineers for research in mechanical problems which constitute ninety per cent of the problems encountered in the design of electrical equipment and machinery. To meet this need some of the industries have established schools for training young engineers in this line of work. The organization and work of one such school was explained. Dr. Timoshenko expressed the opinion, however, that it is not logical for industrial concerns to do graduate teaching and that a fifth or graduate year of work in mechanics at the colleges of engineering is a better plan.

M. O. Withey: LABORATORY TESTS OF A COLUMN.

The members of the group adjourned to the materials testing laboratory where Professor Withey demonstrated the validity of the secant formula by testing to failure a batten-plate column consisting of two ten-inch twenty-pound channels, 119 inches long, under eccentric load.

Thursday, July 28. Afternoon Session

Stephan Timoshenko: ELASTIC STABILITY IN STRUCTURAL ENGINEERING.

There are cases in structural design, Dr. Timoshenko said, when we must consider not only stress but elastic stability. In a strut, for example, if the lateral dimensions are very small in proportion to length, the strut will buckle sidewise under a comparatively small load; failure will be due, not to compressive stress but to lateral deformation. With the improvement of structural materials and increase in their strength it has been possible to make the cross-section of members thinner and thinner, and this leads to conditions in which the investigation of elastic stability becomes important.

Illustrations of this were cited, including rolled structural shapes having thin webs and plate girders whose webs must be stiffened.

Two methods of solving these problems were discussed. One is based on the integration of corresponding differential equations and the other on the analysis of the energy stored in the members. Both of these methods were illustrated by Dr. Timoshenko who applied them to columns and beams. The treatment was mathematical and a condensed summary does not satisfactorily represent the content. Limited space prevents the inclusion of the complete statement.

The latter part of the meeting was devoted to consideration of the reports of committees appointed to study various aspects of the teaching of mechanics. The reports were distributed in mimeographed form and were taken up one by one for discussion. Numerous questions were raised and a few of the reports were modified. After modification they were adopted as representing the consensus of opinion of the entire conference on the points presented. The personnel of the various committees is given on page 532. The reports of these committees, together with the report of the Committee on Resolutions, follow.

Report of the Committee on Resolutions

Realizing the impossibility of adequately thanking those responsible for the success of this, the first Summer Conference for Engineering Teachers, yet being desirous of expressing the sentiment of those fortunate enough to be in attendance here; therefore be it resolved that we take this means of showing our appreciation:

(*a*) To the Society for the Promotion of Engineering Education, whose Staff of Investigation and Advisory Committee on Summer School first sponsored the undertaking and then formulated the plans for this inspiring meeting;

(*b*) To the Carnegie Corporation of New York, whose generous appropriation has made this conference possible;

(*c*) To the University of Wisconsin, which has acted as a kindly alma mater during our brief but pleasant sojourn here;

(*d*) To the College of Mechanics and Engineering of the University of Wisconsin, which has, both as a group and as individuals, been our most gracious host;

(*e*) To that group of loyal workers known as the "Steering Committee" composed of Professors E. R. Maurer, A. P. Poorman, and S. M. Woodward, who, by their own initiative, their counsel, their experience, their forethought and good will, have contributed so largely to the benefits that we have gained;

(*f*) To Professor L. F. Van Hagan we are especially indebted for the successful carrying out of the duties of Secretary of the Conference, and for the time and effort that he has so generously and graciously given in our behalf;

(*g*) To President Frank of the University and to the members of the University Staff who have brought before us in special lectures, in laboratory demonstrations and in critical discussions, a better understanding of the intimate relationships that exist between all the lines of scientific endeavor;

(*h*) To those who have come to us from special fields of teaching and of experience to show us the applications of our work in these special fields and to point out ways of practical improvement.

Signed:

LEROY TUCKER, *Chairman*,
M. K. SNYDER,
J. H. ROBERT.

REPORT OF COMMITTEE NO. 1 ON CORRELATION OF ANALYTIC MECHANICS WITH OTHER SUBJECTS

Your committee feels that better correlation between the principal engineering subjects would aid materially in unifying the engineering curricula and in producing a progressive course of study. No one subject in the curriculum is an end in itself, but is a means to an end and therefore should be arranged to fit the student for succeeding work.

In accordance with these statements, if the organization of the college will permit, your committee recommends:

(*a*) that mathematics and physics for engineering students be taught in the engineering school or department;
(*b*) that the teachers of mathematics and physics for engineering students have engineering training.

In colleges in which the above organization is not possible, your committee recommends:

(*a*) that engineering students be grouped in separate sections;
(*b*) that the course content be arranged to suit the needs of these students.

In any case, your committee recommends that a representative of the mechanics staff confer with the departments of mathematics and physics in regard to the content of their courses for engineering students.

Your committee further recommends that some means of contact between the teachers of mechanics and those of dependent subjects (machine design, structural design, etc.) be established so that duplication of work on one hand and omission of essential topics on the other shall both be avoided.

Report of Committee No. 2 on Minimum Essentials in Analytic Mechanics

In an attempt to get a consensus of the opinions of the engineers and teachers of mechanics gathered here on the question, "What are the minimum essentials in analytical mechanics?," the committee put into the hands of this group a copy of the table of contents of a commonly used text on analytical mechanics for engineers with the request to cross out those portions which, in their judgment, were not included in minimum requirements. It was explained that the committee was not asking for what was taught or presented before the class by any teacher, but wished to know what were thought to be the *minimum essentials*.

The committee had found that the time given to the course in analytical mechanics in the various colleges represented varies from a minimum of fifty-one class periods (three class periods per week for one semester) to a maximum of one hundred ten class periods (a difference of over one hun-

dred per cent). As the time varies so greatly the matter presented to the class must also vary greatly. It was hoped that the method adopted by the committee would greatly reduce this variation, and in this respect the committee was not disappointed.

There was unanimous agreement that certain sections should be omitted, over eighty per cent of those replying to the request agreeing that the following were not among the essentials:

Stresses in flexible cords.
Journal and pivot friction.
Graphical and experimental methods of finding centroids and centers of gravity.
Product of inertia and the connected topics.
Coriolis' law.
Pendulums other than the simple pendulum.
The gyroscope.
Governors.

A majority of the replies in addition to the above, crossed out from the minimum essentials the following topics:

Graphical methods of analysis of concurrent and parallel forces in space.
Couples in space.
Non-concurrent, non-parallel forces in space.
Screw friction, belt friction and rolling resistance.
Motion of projectile.
All unusual components of acceleration.
Instantaneous center.
One method of analysis of kinetics of translating bodies.
One method of analysis of kinetics of rotating bodies.
Center of percussion.
Special applications such as hoop tension in flywheels.
Simple pendulum.
Balancing.
Loss of energy in friction in special bearings.
Dynamometers.
Application of principles of impulse and momentum to any special types of motion of rigid bodies.
Impact.

These items total eight pages more than one-third the pages

of the text used. Accepting the opinion of the majority, the committee begs to present the following as those portions of analytical mechanics which may fairly be taken as minimum requirements:

I. Fundamental conceptions, definitions, and principles such as are given in practically all texts in the introduction and opening chapter.

II. The resultants of co-planar force systems and the equilibrium of co-planar force systems by both analytical and graphical methods.

III. The application of II to the determination of stresses in common trusses and cranes (graphical analysis of stresses should be omitted if courses in graphical statics are given).

IV. Friction, coefficient of friction, angle of friction, laws of friction, with illustrative problems practically confined to bodies on horizontal or inclined plane and the wedge.

V. Moments of volume, mass, area, and line and centers of gravity, both by the methods of the calculus and the method of composition.

VI. Moment of inertia of areas and of solids both by the methods of the calculus and the method of composition.

VII. Rectilinear, curvilinear and rotational motions of a particle omitting the specialized applications such as the pendulum, the projectile, etc.

VIII. Newton's laws of motion and their mathematical expression; rectilinear, curvilinear and rotational motions of solid bodies by one method only, omitting special applications to pendulums, governors, balancing and the gyroscope.

IX. Work, energy and power, omitting special applications to losses in bearings, and to use of special dynamometers.

X. The principles of impulse and momentum and their application to the analysis of motion of a body in common cases omitting impact and applications to gyroscope.

It must not be thought that these items include all that should be presented or taught to the class, but that which should be regarded as the minimum that should be demanded

from the student in a course in analytical mechanics whether the course is presented in fifty-one class hours or in one hundred ten class hours.

Report of Committee No. 3 on Classroom Methods

The Committee on Classroom Methods can make no specific recommendations regarding the proper division of class time between lectures, recitations, quizzes and other forms of exercise. Probably this question cannot be satisfactorily answered by any individual or group, as the answer depends upon the circumstances of the individual case. The talents and ability of the instructor, the nature of the subject matter, the characteristics of the group of students, the time available, and many other factors control the method adopted.

The successful teacher doubtless uses many different methods during any course. Under a varying procedure, whether the variation be to suit changing needs or for the sake of variety itself, the students will derive more pleasure and benefit from their work than when the same method is rigidly followed day after day.

Instead of attempting to set up a system, the committee submits a discussion of a number of the commonly recognized methods. The conditions, advantages and limitations of each type of exercise will be stated as distinctly as possible.

(*a*) Lectures.

1. Probably required to some extent in all courses.
2. Useful when introducing new subject.
3. Useful for forcing attention and interest for difficult portions of theory or important fundamentals.
4. Instructor must make lecture interesting.
5. Instructor must understand students' viewpoint.
6. Avoid delivery which bores or tires the student; use simple direct statements.
7. Use clearly drawn blackboard illustrations, and specific examples and analogies to help student grasp the content.
8. Make lecture short and snappy.
9. Permit students to interrupt with pertinent questions.
10. Talk *to*, not at or beyond, the students.

(*b*) Class Discussion.

1. Probably the most generally effective method.
2. Let students start discussions by their voluntary questions about the ideas that have puzzled them.
3. Have students answer each other's questions, voluntarily, if possible.
4. Break the discussion into short specific statements, so that all can have a chance.
5. Train students to refer to specific items in text or problems that cause difficulty.
6. Do not make discussion an obvious oral quiz; encourage freedom of expression.
7. Occasionally refer back an unclear situation for further analysis and discussion at next session.
8. In difficult cases give a start to the solution and let students lead themselves along step by step.

(*c*) Oral Quizzing.

1. Not particularly valuable as a distinct exercise.
2. Grades cannot be given accurately.
3. Students, who are not reciting, tend to disregard the subject.
4. A limited amount of this type of exercise can be worked in by the instructor under Class Discussion (*b*) above.

(*d*) Blackboard Work.

1. Required for problems and demonstrations.
2. Work should be easily visible to entire class.
3. Work must be distinctly written and simply arranged.
4. Systematic and brief methods desirable.
5. Is monotonous if entire class works at board every day.
6. Instructor cannot give full attention to accuracy and method of all students in limited time.
7. Depends upon blackboard space available.
8. Relatively ineffective for grading students.
9. Good for getting work before class for discussion and criticism.
10. Most effective if only a few students are at the board at one time.
11. Assign only so many problems as can be completely discussed in the same period.

(*e*) Laboratory Exercises.

1. Valuable for demonstrating fundamental theory.
2. Good apparatus must be available.

3. Students should have opportunity to work the apparatus themselves, when practical.
4. Should be accompanied by the development of theory and the working of sample problems.
5. Are effective in creating interest and destroying monotony.
6. Use for demonstration; not for extra report work.

(*f*) Computing Periods.

1. Require special attention in scheduling.
2. Furniture must be suitable.
3. Problems must be carefully planned.
4. More difficult or longer problems can be given.
5. Instructor should always be available to give assistance.
6. Most effective if instructor passes from one student to another to watch progress and to encourage questions.
7. Work of students should be graded.
8. Some students may not work as effectively in organized group as in their own rooms.
9. Limited amount of computing periods feasible.

(*g*) Conferences.

1. Highly desirable to combine with any system.
2. Students should be encouraged to bring difficult questions to instructor for office conference.
3. Instructor has opportunity for better understanding of student's problem.
4. Private conference promotes cooperation.
5. A method of fitting work to ability of student.
6. Instructor should have plenty of time available.

(*h*) Written Papers.

1. In mechanics generally problem work.
2. All of students' work should be examined by instructor.
3. Encourage systematic analysis and solution.

Report of Committee No. 4 on Written Tests in Analytic Mechanics

In order that this committee might have some material upon which to base a report, a questionnaire was prepared and distributed to each member of the conference. Twenty-six were returned, carefully tabulated, and the tabulation stud-

ied. Attached is a copy of the questionnaire with the more important results. (The tabulated results of the questionnaire are omitted by reason of limited space.)

These results indicate that a one-hour written test should be given every six to ten class recitations and that the value in determining the term grade of the student should be about one-third.

The short test is also used by a majority of teachers of engineering mechanics. Of those using it, sixty per cent give two or three out of every five assignments. As to the value in determining the final grade this committee feels that it should have the same weight as a daily recitation grade and, together with the recitation grade, have a value of one-third.

The final examination should contain from eighty per cent to ninety per cent problems with the remainder of the test derivation of theory, definition and discussion of principle. It should be possible in a three- or four-hour final examination to cover at least fifty per cent of the minimum essentials of the course. The weight given the final examination should be about one-third of the term grade.

As to the advisability of a comprehensive general examination over the first two years' work before starting the third year work, the conference is about equally divided. Because of the lack of organization for such a test, and its doubtful value even if instituted, this committee thinks that it is not feasible and should not be considered at this time.

Report of Committee No. 5 on Home Problem Work

Your committee on Home Problem Work submits the following report as an ideal to be attained, recognizing the fact that the suggestions and recommendations made may not prove feasible in every case.

1. Type problems based on daily assignments should be given. The number of problems should depend on the time required for their solution which should not exceed an average of one hour for the average student.

2. If the instructor requires problems to be handed in by

the student, he should examine, indicate errors, grade and return them promptly.

3. The student should be encouraged to correct errors on the original copy. The committee suggests that conference hours be assigned at which time the students may receive individual assistance.

4. Work handed in should conform to a standard of arrangement, neatness, legibility, consistency and accuracy which has been previously agreed upon by members of the department.

5. In general, it is more economical of a student's time to give answers to homework problems but student should be encouraged to develop independent checks.

6. Very little weight should be given to the homework grade in determining the final term grade of the student, though it may be taken into consideration in determining doubtful grade classification.

Replying to the question, "Do you teach the student how to use his slide rule to the greatest advantage?," which was submitted to the committee for consideration, the committee wishes to say that some specific training in the use of the slide rule should be given to the student if he has not had previous training.

Report of Committee No. 6 on Sample Problems in Analytic Mechanics

(The report of this committee consists of a compilation of sample problems submitted by members of the conference. Most of the samples took the form of the usual content question requiring the student to derive a formula, state a principle or solve a problem. Some, however, were of the true-false type answered by indicating whether the student found the statement to be correct or incorrect. The compilation of problems is a valuable one but is too extensive for inclusion in this document. It may be consulted at the office of the Director of Investigation, 33 West 39th Street, New York City.)

Report of Committee No. 7 on Apparatus for Teaching Analytic Mechanics

(The report of the committee is essentially a carefully prepared collection of experiments which may be given, and a discussion of procedures which may be advantageously followed in experimental work connected with the teaching of mechanics. The report is extensive and lack of space precludes the possibility of publishing it. It may be consulted at the office of the Director of Investigation, 33 West 39th Street, New York City.)

Report of Committee No. 8 on Organization and Administration of Courses in Analytic Mechanics

Part (*a*). What is the best form of faculty organization to cover the related fields of mathematics, physics, analytic mechanics, mechanics of materials and materials testing laboratory, hydraulics and other closely related subjects?

In consideration of this question two types of engineering schools were included; *first*, the small engineering school which we find as part of an arts college, numbering probably two or three hundred students in technical courses, and *second*, the engineering college of large enrollment constituting a part of a university.

1st. (Small engineering school giving perhaps only one degree in engineering.)

Department of Physics—handling subjects of physics and analytical mechanics.

Department of Mathematics and Engineering—teaching all of the mathematics and technical courses.

2d. (The large engineering school giving separate degrees in engineering.)

Two separate departments of Physics and Mathematics under the direct administration of the engineering college.

In the engineering college individual curricular departments would be provided, such as Civil, Electrical, Mechanical, Chemical, Architectural Engineering, etc., and the non-curricular department of Applied Mechanics, handling the basic courses of analytical mechanics, strength of materials and testing laboratory.

Part (*b*). What is the best subdivision into courses for the above subjects, at what place in the curricula should these courses be scheduled and how much time should be allotted to each?

Considering the basic fundamental nature of these courses as applying to engineering, no attempt was made to differentiate between the larger and smaller engineering schools.

Mathematics

Algebra	three hours	first semester	Freshman Year.
Trigonometry	two hours	first semester	Freshman Year.
Analytics	four hours	second semester	Freshman Year.
Differential Calculus	five hours	first semester	Sophomore Year.
Integral Calculus	four hours	second semester	Sophomore Year.
Differential Equations	two hours	(elective)	Junior Year.

Physics

Three hours recitation and two credit-hours laboratory, first and second semesters—sophomore year—each semester totaling ten hours.

Analytic Mechanics	five hours	first semester	Junior Year.
Mechanics of Materials	three hours	second semester	Junior Year.
Mechanics of Reinforced Concrete Construction	two hours	second semester	Junior Year.

Materials of Construction and Materials Testing Laboratory

One hour recitation and one credit-hour laboratory—second semester—Junior year.

Hydraulics ..... three hours second semester Junior Year.

Hydraulic Laboratory one credit-hour second semester Junior Year.

Part (*c*). What is the best grading system and what should be the passing grade?

It was the opinion of the committee that, independent of any grading system, the passing grade of work would be automatically determined as representative of that grasp of the minimum essentials, which, in the estimation of the instructor, would permit the student to continue his future work with profit.

However, we recommend that the grades in recitation courses should be based only on work which is done in the classroom under the direct supervision of the instructor.

Report of Committee No. 9 on Objectives in Teaching Analytic Mechanics

From the standpoint of the student, the objectives in mechanics, in order of their importance, are:

1. To acquire an understanding of the effect of force systems on bodies.
   (*a*) To acquire a knowledge of the essentials of mechanics and to learn to express this knowledge in exact and usable form.
2. To sharpen the observation powers, develop judgment and appreciation of value in engineering. To identify the problem and select the data pertinent.
3. To practice and fix in mind the mathematical and physical principles already learned.
4. To assist in the development of technique of several methods of computation.
5. To prepare some theoretical basis for advancement after graduation.

Following the consideration of the reports of the committees on the above matters, Professor Woodward offered the following resolution which was unanimously adopted:

Be it resolved: that in the opinion of this conference there should be offered, at every engineering college, an elective course in Advanced Mechanics, open to graduate students and to senior students possessing marked ability, as shown by their previous work in this line.

Thursday, July 28. Evening Meeting

A. N. Talbot: RESEARCH IN ENGINEERING COLLEGES.

Professor Talbot dealt with the function of the engineering school in contributing to knowledge through research. "While we must recognize," he said, "that teaching is the first province of the engineering school and that the good teacher deserves proper treatment both in salary and promotion, even though he has done no productive research, I believe that contact with research will give a teacher a clearer vision and a sounder understanding and make him a better teacher."

Contact with research work, in the opinion of Professor Talbot, will keep the teacher from advancing only the mere formal expression of accepted generalizations, from worshipping the formula and the law, and from teaching the idea that the ordinary assumptions are always accurate. It will keep him from getting into a rut, from becoming frozen to form and becoming old at thirty. It should help him to keep alert to new ideas, to new applications, to new interpretations. It should help him to inspire and stimulate the student. It should help to give him a continued vision into the active world of engineering about him.

Turning to the agencies which conduct research, Professor Talbot pointed out that the engineering college is only one of a number of them. Doubtless governmental agencies and private industries will continue to carry out many of the large projects and yet there is, undoubtedly, an important place for the engineering college in research. It has the equipment and the trained personnel for the work; the atmosphere of research will stimulate the student and the teacher alike. The contributions that have come from engineering colleges already form an extensive and impressive list. Although the difficulty of obtaining funds is a serious problem with the smaller colleges, there are, fortunately, some research problems that do not require large funds nor long continued work. It is probable, however, that if those who control funds can be shown that there is need for the solution of a problem and

that a man capable of doing the work is available, grants of money can be obtained. There are men today in small institutions who are bringing out results worthy to be ranked with the best.

Considering the question "What can be counted as research?," Professor Talbot stated that research is a comprehensive term. It may apply to large and important problems involving experimental work continued from year to year; but it also includes smaller problems, detached questions, parts of problems, reconnaissance researches, and new methods of attack on analytical problems such that they may be attacked by an individual without the command of large resources or skilled assistance. Professor Talbot would not, however, include in the category of research work mere mental exercises nor puzzles and puzzling questions whose sole purpose is to exercise the mind; neither would he include incidental, accidental, curious or unimportant matters. Real research, even for minor problems, requires much time, thought, study, care, judgment and pertinacity.

Professor Talbot said that it seemed fitting to emphasize the importance of reporting results of research in such form that they would be of the greatest possible use. Something more than mere compilations of data, even if they are coupled with good English, is needed. Reports must be written with an understanding of the psychology of the reader.

Concluding his remarks Professor Talbot said that it should be accepted as a truism that it is a function of the college or university to make contributions to science and to disseminate knowledge. He believes it is a real duty of the engineering college to promote engineering science and to aid in the advancement of the profession and he feels, further, that the engineering teacher has a duty and a responsibility in the matter of research that will yield valuable results to the engineering student and the engineering world.

(Part IV, which concludes the Proceedings of the Summer School for Engineering Teachers, will appear in the March issue of the JOURNAL.)

ENGLISH FOR ENGINEERS AT THE UNIVERSITY OF NORTH CAROLINA.

A. C. HOWELL,

Assistant Professor of English in Charge of English for Engineers.

Since the organization of the School of Engineering at the University of North Carolina, English has been given a prominent place in the curriculum. It has always been the policy of the administration to see that students were taught to express themselves in reasonably clear and correct English, both in writing and in speech. In order to secure this result, the Department of English has made every effort to set up a course which would meet the needs of the technical man. For this purpose a division of Engineering English was established and enough instructors were detailed to it to carry on the work properly. The staff has been fairly permanent since its organization, and thus the courses established have been carried on under the same general tradition. One result of this uniformity has been that the courses have secured a reputation among the students and are rather definitely accepted as an essential part of the training of the engineer.

Students have a way of advertising a course among themselves, and the courses in English have a way of becoming notorious as totally unnecessary for the engineer—something that he must wade through, doing as little work as possible. This feeling is unfortunately condoned rather than condemned by many members of technical faculties, so that the students are rather supported in their feeling that English is an evil to be avoided rather than an opportunity to be grasped. No course can be successful under such a reputation, nor can a teacher do his best work with a group of unwilling students. At the University of North Carolina no such spirit exists. The technical faculty and the division of Engineering English work in perfect harmony, and every student is made to feel

the importance of his work. His fellow-students who have had the courses strengthen this feeling by telling him of their experiences in the courses, so that the work gets off to a favorable start. This impetus does much to secure good work from the students and is more than a little responsible for the current campus opinion that the courses in Engineering English are hard but valuable.

The relationship that exists between the instructors in the English work and those in the technical departments has already been mentioned. No finer spirit could exist than the one which now obtains in the School of Engineering here. The men in the English department are considered a part of the Engineering faculty, are given places on faculty committees and are in every way made to feel a part of the organization. In turn, they frequently extend their services in furthering the interests of the School by acting as editors of Engineering bulletins, circulars, and other publications of the School. A member of the English Department is on the Administrative Board of the School. On the other hand, the Dean of the School is always ready to see that good teachers in the English department are properly recognized by the University. This *esprit de corps* has a salutary effect upon the students and instructors as well. Whereas in most institutions, assignment to Engineering sections is almost a punishment for the young instructor in English, here it is looked upon with favor, and as a result, young men who are well trained and thoroughly capable are assigned to the English for Engineers division.

Engineers are taught in separate sections all through their English courses; they are never thrown with men of other schools whose interests are at variance with their own, with the result that the whole energy of the course can be focussed upon their problems. Everything in the course is aimed at their particular needs and for their particular type of mind. Thus much energy is saved and the course has more meaning for the engineering student. Moreover, the student is at his ease. He is not forced to express himself to a hostile audi-

ence of students and he feels perfectly free in the classroom to question any procedure which appears to him to be out of keeping with his needs. This gain in class-room ease and economy of direction more than offsets any loss which might be felt from lack of contact with students in other schools of the university. Such contact is plentifully found in the outside activities of the students, and as a rule they resent having outsiders in their classes. The student engineer is encouraged to feel that his English classes are *his own*, and he responds to this appeal.

II

In its general plan, the course as mapped out in 1922 is still in operation. It consists of the following courses, and extends throughout the four years of the undergraduate course.

Year.	Subject.	Time Devoted to Course.
I.	Composition	Two hours per week throughout the year and conferences weekly.
II.	Public Speaking	Two hours per week throughout the year.
III.	Composition	Four hours per week for sixteen weeks, outside readings, conferences.
IV.	Literature	One hour per week for two quarters.
V.	Contracts and Specifications	One hour per week for one quarter.

Except in the case of the senior work, sections are not permitted to run over twenty so that ample time may be allowed each man for conferences and individual attention in class. The University does not permit the use of correctors, and each paper submitted by the student is read by his own instructor and returned for revision before a final grade is given it. Thus the student knows that his work is given careful attention by the man who is in the best position to know what he should be able to do, and the instructor is able to spot the weaknesses of his students so that he may give them a proper discussion in classroom and conference.

Professor L. B. Wright in an article in THE JOURNAL OF ENGINEERING EDUCATION for October, 1926, explained in some detail the work done in the Freshman course in composition.

Two special features are worthy of note in passing. They are the conference system and the cooperative plan used in the third quarter's work. Each student is given a conference which lasts from fifteen minutes to a half hour every week. In these conferences every paper is gone over in detail with the student, the instructor noting the errors and securing corrections from the student then and there. In some cases the instructor may actually mark the paper in the presence of the student, or may have it corrected by the student and finally graded during the conference. Each theme is listed on a specially prepared report form which has a detailed list of errors which may be checked. Thus an instructor has at hand data on the complete file of the student's papers, showing the prevalence of errors of any given type. This serves as a record of achievement for the student and has proved an incentive for more careful work.

During the third quarter of the Freshman year, the English course becomes amalgamated with a course designed by the Engineering School to develop observation and to familiarize the student with some of the more common phases of engineering work in actual practice. This course consists of a series of inspection trips to various engineering works such as the University filter plant, the power plant, a sewage disposal plant, and others. The trips are planned by the department concerned with the particular type of work to be visited; the students hear a lecture on what they are to observe, and are then conducted over the plant by the technical instructor, where they take notes, secure measurements and photographs, and prepare data to answer the questions given on a syllabus of the trip. From these trips, the students prepare reports illustrated with drawings and photographs. The English instructor is called upon to help in the organization of these reports and grades them for English. The technical instructors grade them for the observation and the technical knowledge displayed, and the drawing instructors on the drawings which are included. Such a coordination of effort impresses upon the student the fact that English is a part of

his technical work and is so recognized by his technical instructors. He also learns the rudiments of report writing, especially in matters of presentation, form and make-up. Some of the reports submitted by Freshmen in this course are as carefully prepared and as attractive as many submitted in actual practice and are illustrations of the success of this course from the point of view of student interest and attainment.

The work of the sophomore year, the course in public speaking, will be treated in a separate paper to appear later in this journal. Suffice it to say that in this course too, the student engineer is made to see the connection between his career and the course he is pursuing, and the work itself is adapted to him in every detail. Interest in this course is easily aroused by the fact that hardly a speaker in addressing the engineering students at their clubs fails to stress the importance of this phase of their training, and sometimes by example as well as precept. During this year the student's writing is not neglected, as he is expected to turn in briefs of his speeches and at times a draft of the speech itself, as well as outlines of assigned readings.

III

During the junior year the students in the Engineering School are on a cooperative schedule, which divides their time between school and a job with some engineering concern where they receive practical experience. The course in English is designed to tie up with this phase of their training to an extent, and is necessarily cut into sections to fit the divisions of the students' time. The first section of seven weeks is taken up with a rapid review of some standard handbook for the elements of composition, followed by an intensive study of the business letter as it applies to engineers. The following types are given attention: inquiries, orders, adjustments, instructions, applications, business promotion letters and sales letters. When the student finishes this course, he is able to write a fairly correct and effective letter; at least he is fully cognizant of the best practice in modern business correspond-

ence. The course is made more interesting by the use of a large number of examples, horrible as well as excellent. That the students realize the value of such a course is shown by the fact that they frequently bring in their personal business letters to the instructor for correction and that they write in long after they have left school to ask questions about practice in correspondence, or to secure information about recommended books to give to their friends.

The second section of the course is devoted to a study of the technical periodical, with practice in writing the various types of articles found in it. This course is amply illustrated by the use of over a hundred technical publications which are available to the students in the library. Each student is assigned one of them for careful study as the basis for an oral report to the class. As a culmination of this study, student editors elected by the class select the best papers submitted by the class and publish them in a magazine sponsored by the School of Engineering, the *Carolina Engineer*. Some excellent work has been done in this field, and through it the students are given an opportunity to see their work in print. The magazine has caught the interest of the students so well that they have made a careful study of the field of Engineering College magazines with a view of making the magazine a permanent publication of the entire school rather than merely a product of one class.

Technical report writing occupies the next period of class work. In this section of the course the student is given opportunity to try his hand at writing the various types of reports used in engineering practice. It culminates in an examination report of some length on which the students are given six months to work, thus insuring them plenty of time for the collection of data and for careful rewriting. This report is one of which they are justly proud, and on it they spend large amounts of time. The usual length is from twenty to forty typewritten pages, amply illustrated with title-page, epitome, table of contents, conclusions and recommendations, and appendices. The students frequently choose some project which they have examined while on their co-

operative work, and they are sometimes asked to submit their reports to the concerns whose projects they have studied. Several times their reports have been of commercial value to these firms, and parts of them have appeared in print. Ample illustrative material for this work is provided by the library and the files of the instructor.

In connection with this phase of the work both methods of collecting and of presenting material are treated, and the questionnaire, the interview, the elements of graphical presentation of material, and various devices for securing attention and interest are studied. All through the course students are expected to do several hours of outside reading from a wide range of materials including texts on the subjects treated, magazines, reports, and general literature.

The final section of the course is given as work outside the classroom and consists wholly of reading from a selected list of books and writing reports on them. By this means the student is familiarized with worthwhile books in the various fields of literature and learns something of them by the careful study he must make in order to write an acceptable report. The student is told that a part of his training in English should be devoted to some of the elements that make up the educated man, and that one of these is a knowledge of literature at least as to its types and purposes. The writer feels that such a course as the one outlined above will do more than a little to overcome the diffidence so characteristic of engineering students when they are approached on any matter relating to the fine arts.

Notes: Another book may be substituted for any of these recommended by permission. Each report is to be done under the honor system, must be certified as original, and contain the following items: (1) Name of author and title of book, with date of publication. (2) Sketch of author's life, not to exceed fifty words. (3) Summary of book as a whole, not to exceed 250 words. (4) Your own criticism of book, about five hundred words in length.

The reports are usually about a thousand words in length and at least half of each is devoted to a critical discussion of

the book read. Students are told that great frankness is expected from them as to why they did or did not like the books they have read, and that the grade is based on the merit of the report, not on their opinions. In many cases they read several of the books in the list voluntarily, although they are permitted to report on but one. They are given three months in which to submit these reports.

The course in reading serves as a preparation for the work of the senior year which has been called the dessert of the English course. During the first quarter the students are given one or two lectures on the short story as a literary form and on its history, to familiarize them with its terms and forms; then each student is assigned a volume or a writer on which he presents a report in class. These assignments range from the "Panchtantra" and the "Arabian Nights" through the "Decameron" and down to Ambrose Bierce and Sherwood Anderson.

During the second quarter practically the same procedure is followed with the novel, except that in this case the most important novels are selected and each student reads and reports on one. Thus all the class is made familiar with the great stories and novels of our literature and the burden on any one student is never very heavy. The students frequently carry their books to the senior rooms of the various divisions of the Engineering school and pass them around, so that usually more than one student actually reads them, though this is not required. No examination is given in this course, and great freedom in the class-room is permitted, so that everyone enjoys the weekly hour.

The final quarter of the work is given over to a rapid survey of D. T. Mead's "Contracts and Specifications," with several papers to give practice in the forms studied.

Thus it is clear that the English course for engineers at the University of North Carolina is designed to meet the needs of the engineering student and to arouse in him interest in this phase of his training, that it does not neglect the phases of literature which are of some value to him, and that it is made profitable and enjoyable.

THE PROBLEM OF ENGINEERING EDUCATION AND THE SMALL COLLEGE.*

BY H. W. McKIEL,

Brookfield Professor of Engineering, Mount Allison University.

It is not my intention to offer any original remarks upon the subject of the small college and engineering education, as my experience in that field is not wide enough to warrant such presumption. I thought, however, in view of the discussions which have occurred in previous meetings of the Society and of articles published in the JOURNAL, that a brief account of the system developed in the neighboring Maritime Provinces of Canada might be of interest to the members.

This system resulted somewhat from choice on the part of the colleges concerned, but necessity also had a large share in its birth and development. To understand this statement properly, a short summary of the conditions existing in the Maritimes in the last century and the early years of the present century should be given. It must be remembered that the combined population of these three Provinces to-day is only about one million and their combined area some fifty thousand square miles. The people originally were mainly English and Scotch and, as is well known, these races, particularly the latter, take their religion and politics quite seriously, and also place a high value upon education. Thus it was due to these religious and political differences as well as to the sparsity of the population that there grew up to serve the educational needs of this very small and scattered population eight degree-conferring colleges and universities, as well as several others doing work somewhat comparable to that of the modern Junior College. The degree-conferring institutions in order of their age were King's College, then at Wind-

* Presented at the 35th Annual Meeting of the Society at the University of Maine, June 27–30, 1927.

sor, N. S., now affiliated with Dalhousie in Halifax; an Anglican School founded in 1790 and hence the oldest colonial college in the British Empire; the University of New Brunswick at Fredericton, N. B., founded in 1800 as the College of New Brunswick and assuming its present name in 1859; Dalhousie University, Halifax, founded in 1818, an independent college, but one to which Presbyterian support had always been given, and with which the Presbyterian Theological College was affiliated; Acadia College, Wolfville, N. S., founded by the Baptist Educational Society in 1838; Mount Allison College, Sackville, N. B., founded under the auspices of the Methodist Church in 1843; and St. Francis Xavier College, Roman Catholic, founded in 1852 at Arichat in Cape Breton, but later removed to Antigonish, N. S. Subsequently the Roman Catholics established four or five more schools, several of which were degree-conferring, and at least one of which, St. Mary's College in Halifax, became interested in technical education and associated with the present system.

Most of these colleges held University charters and so were privileged to carry on instruction and grant degrees in any or all faculties as the occasion arose or necessity demanded. During the early period of their development their attention was confined almost entirely to Arts and Theology, the curriculum being so designed as to emphasize slightly their denominational character. By the year 1875, however, some attention was being given to Applied Science, the activity of the mining industry in Nova Scotia, I presume, being largely responsible for this. As the youngest of these institutions had at this time completed more than a quarter of a century of existence, and the oldest almost a century, during which time the partisan forces which had led to their founding had waned but little, it was only to be expected that these same forces, backed by the traditions the various colleges had established, would urge each institution to make use of its charter privileges and engage actively in the new field of instruction. This proved to be the case, for in 1899 St. Francis Xavier, at Antigonish, being nearest the mining and

steel producing regions of Eastern Nova Scotia, and seeing the need of trained men in these industries, employed several prominent practising engineers to give casual instruction in the elements of mechanical and civil engineering, additional building accommodation being provided. In 1900 full time permanent instructors were engaged for the departments of mechanical and electrical engineering, and a new department of mining engineering was organized. Thus St. Francis was now giving instruction in the four main branches of engineering. In 1901 the Superintendent of Education for Nova Scotia very highly endorsed this training and following his commendation public interest in technical education quickened, and the people of Eastern Nova Scotia petitioned the legislature to aid this school and so encourage the development of this branch of education. The other colleges, not to be outdone, now began to take keener interest in engineering and in 1902 Dalhousie established the second engineering school in the provinces—"A School of Mines"—which provided a four-year course leading to the degree of B.E. The work was done, at first, by practising engineers in the city, but by 1904 a Professor of Mining Engineering had been appointed, and in 1906 one in civil engineering was added. Degrees were then given for the first time in mining and civil engineering. In the meantime both Acadia and Mount Allison universities, though more removed from industrial centers, had heard the call and established faculties of Applied Science—Mount Allison in 1903 and Acadia in 1904. These institutions made no effort to do the full course but confined their attention to the work of the first two years of the regulation four-year course. Affiliation with McGill University was secured, the course being modeled on that of this institution which had even then adopted a uniform first and second year for all branches of engineering. Acadia added one full time instructor to carry on this work and Mount Allison two, one of whom is one of our present hosts, Prof. J. W. Sweetser of the University of Maine. In the meantime, King's College, Windsor, entering the race, had established a technical department in Sydney some 250 miles east of the parent body.

The colleges soon discovered that engineering education was a most expensive undertaking and that large endowments would be required to maintain a suitable standard. These endowments not being available, it necessarily followed that none of the colleges could long continue to carry on work of high grade. The mining profession recognized this fact, and in 1906 the Nova Scotia Mining Society became interested and invited the colleges to send representatives to a joint meeting to discuss the whole situation. This the colleges gladly did, and after a protracted discussion it was unanimously resolved that the N. S. government be asked to provide a central institution in which the last two years of a four-year course might be given, admission to this school to be obtained on certificate of having completed the first two years at one of the regular colleges. This the Nova Scotia government undertook to do and in 1907 the Nova Scotia Technical College was founded on the suggested basis, the colleges undertaking to confine their work along engineering lines to the less technical part of the course comprising the first two years. Each of the cooperating institutions was given representation on the governing body of the Technical College, which body also includes the faculty of the college. It meets at least once a year to lay down the required courses or to make any revision deemed advisable. With one exception, the University of New Brunswick, all the Maritime Colleges entered this agreement, though Mount Allison and Acadia retained, and still do so, their affiliation with McGill.

After this historical sketch I shall now deal more particularly with the course as given at Mount Allison, with which institution I am most familiar. In its first year, 1904, the course was fivefold, separate curricula being laid down for each of mechanical, electrical, civil and mining engineering, and architecture, but by 1905 a standardized uniform two-year course for all branches of engineering was developed and architecture was dropped. This uniform course was substantially the same as that given in the other colleges. It consisted of the following:

FIRST YEAR.

Mathematics—9 hrs. per wk.
- Geometry—The equivalent of Books IV, VI, XI and part of V of Euclid.
- Algebra—To Binomial Theorem.
- Plane Trigonometry.
- Analytical Geometry.

Physics—6 hrs. per wk.
- General Physics, 2 hours.
- Engineering Physics, 4 hours.

Descriptive Geometry, 5 hours per week.
Lettering and Freehand Drawing, 3 hours per week.
Shopwork—Carpentry, Wood Turning and Forging, 6 hours per week.

SECOND YEAR.

Mathematics—8 hrs. per wk.
- Advanced Algebra and Trigonometry.
- Differential and Integral Calculus.
- Mechanics.

English—Freshman English, 3 hours per week.

Chemistry—5 hrs. per wk.
- General Chemistry, 3 hours per week.
- Qualitative Analysis, 2 hours per week.

Kinematics of Machines, 3 hours.
Mechanical Drawing, 3 hours.
Surveying and Mapping, 6 hours.
Materials of Construction, 1 hour.
Descriptive Geometry, 6 hours one term.
Shopwork—Chipping and Filing and Foundry, 3 hours.

The matriculation to this course was the same as for Arts, with the exception of the language requirement, only one foreign language being required. This standard was comparable with that of all other Canadian universities and is, I believe, in Mathematics, Science and English about the same as the average university matriculation in the United States. The other cooperating colleges did not teach as much Mathe-

matics in their course as we at Mount Allison did, as they were able to require senior matriculation in Mathematics for entrance. This grade of work has never been taught in the New Brunswick secondary schools, and hence had to be included in the first year of our course. It was not an unmitigated evil, however, for the superior type of instruction received in the college justified its inclusion, even had the advanced matriculation requirement been attainable.

As time passed and possible improvements suggested themselves, or as McGill University or Nova Scotia Technical College changed their requirements, some changes were made. In 1908 a course in Elementary Surveying was added to the first year and all Mathematics prior to Calculus placed in that year, a course in Spherical Trigonometry being then included. In 1911 a three-hour course for one term in Graphical Statics and an optional course in General Geology were made part of the work of the second year. In 1912 the Physics work of the first year, as previously given, was discontinued, and a special course in General Physics for engineering students was developed, this course consisting of four lectures and one laboratory period per week. At the same time an advanced course in Electricity and Magnetism—two lectures and one laboratory period a week—was added to the work of the second year, as well as an extra hour in Qualitative Analysis. Later an elementary course in Mechanical Drawing was provided for first year students and all the Descriptive Geometry was placed in that year, as was also the course in English. In 1921 Shopwork requirements were reduced to six hours per week in the first year, and in 1925, following the lead set by McGill University, all Shopwork courses were dropped. Students now wishing to attend McGill University must spend, at some time before receiving their degree, a specified period of employment with industrial concerns engaged in engineering work. Those students wishing to enter Nova Scotia Technical College must fulfil the same regulation or take a course in Shopwork given by that college in September prior to their entering their third year.

The greatest change was made only last year and came into effect in September, 1926. In common with the other engineering colleges of America, we at Mount Allison had felt for some time that our students were not receiving the full value of their opportunities, in a word that while they were being technically trained their general education left something to be desired. McGill University had also come to a similar conclusion and had decided to increase the amount of general education in their course. The secondary school system of Quebec Province not being sufficiently developed to render practicable a complete senior matriculation requirement, as had been done elsewhere, McGill decided to require a year in Arts as the entrance requirement to engineering. This suited us in New Brunswick very well, as no senior matriculation could be obtained there. The various cooperating colleges all had similar views on the matter and in the spring of 1926 laid down new entrance requirements for the colleges and somewhat altered the previous uniform two-year schedule. Taking advantage of these changes we have adopted a new three-year programme for those entering with the same matriculating standard as previously, but for the student who can secure a senior matriculation standing, the course can be shortened to two years. We prefer, however, to have him spend the three years in college. This course followed by two years in a technical college or faculty of Applied Science leads to the degree of B.Sc. in some branch of engineering. The new course, from which we hope better results, is as follows:

FIRST YEAR

Plane and Solid Geometry and Algebra, 5 hours per week.
Plane and Spherical Trigonometry and Analytical Geometry, 4 hours per week.
English (Freshman English), 3 hours per week.
French or German, 3 hours per week.
General Physics, 4 lectures and 1 lab. period.
Freehand Drawing and Lettering, 3 hours per week.

Elementary Mechanical Drawing, 2 hours per week.
Total: 19 lectures, 8 hours lab.

SECOND YEAR.

Differential and Integral Calculus, 3 hours per week.
General Chemistry, 3 lectures and 3 hours lab.
English (Sophomore English), 3 hours per week.
A second course in Modern Language or a course in Modern History, 3 hours per week.
Materials of Construction, 1 hour per week.
Engineering Problems, 2 hours per week.
Descriptive Geometry, 1 lecture and 4 hours lab. per week.
Drawing, 3 hours per week.
Elementary Surveying, 1 lecture per week.
History of Science, 1 lecture.
Total: 18 lectures and 10 hours lab.
(Surveying Camp—3 weeks between second and third year.)

THIRD YEAR.

Mechanics (given by engineering department), 3 hours per week.
Mechanics of Machines, 1 lecture, 3 hours lab.
Graphical Statics, 1 lecture, 2 hours lab.
Qualitative Analysis, 2 lectures, 4 hours lab.
Advanced Magnetism and Electricity, 2 lectures, 3 hours lab.
Surveying, 1 lecture, 2 hours lab.
Engineering Drawing, 3 hours lab.
Economics, 3 lectures.
Total: 13 lectures, 17 hours lab.

The above course, as given at Mount Allison, is substantially the same as that given by the other cooperating colleges, only slight variations occurring. There are no restrictions placed upon either the individual college or the instructor, other than a general outline of the course to be covered and the minimum number of hours per year to be given to it. Each instructor uses the text he prefers, sets his own examination papers from it, and marks these papers himself. The students com-

pleting the course receive certificates to that effect, and these certificates admit them to the advanced years of the course either at McGill University, Nova Scotia Technical College, or elsewhere.

On first thought such a course, carried on in widely separated localities by different instructors, trained in quite different institutions, who come together only once or so a year, might seem capable of producing only chaos, but twenty years of experience have shown that this is not the case. The reverse rather is true, the plan having proved sufficiently successful to enable men with the Mount Allison certificate to complete the engineering course in two years, not only at the two original participating institutions, McGill University and Nova Scotia Technical College, but also at Queen's University, Kingston, with which our engineering department is now affiliated, the University of Toronto, and even, on occasion, with the aid of a summer school at the Massachusetts Institute of Technology. It is rare for one of our men to take longer than two years to complete his course and almost unheard of that any fail to graduate. I understand the same can be said of men from the other colleges.

This plan having been followed for almost a quarter of a century, it would be expected that some defects would appear and possibly also some advantages over the more orthodox system. After fifteen years' personal experience only one serious defect appears to me and that is the lack of a proper perspective of the whole course, which necessarily occurs when only part of a course is given at the institution where a student commences his work. This sometimes renders difficult the linking up of subjects in the earlier years with practical engineering and also causes perplexity upon the part of the student at the time he leaves the college and enters the technical school, as to which branch he shall follow, now that he must choose. He has not the clear idea as to what the later years of the course include that he would have had he been receiving his training in the regular way. To obviate this we have followed the plan of having a series of lectures de-

livered each year by engineers in active practice, on the opportunities that each field offers and the type of work to be expected in it. This has proved advantageous in a rather unexpected way, as many of these speakers have stressed strongly the need for sound training in the very subjects in which we have frequently found the most difficulty in interesting the embryo engineer.

To offset this disadvantage a number of advantages have become apparent, some of which may be cited. In the cooperating colleges the number of students on the engineering course ranges from thirty to sixty. To instruct these there are usually employed two or three graduate engineers in addition to the members of the regular arts faculty. The enrolment of the college itself is limited and a competent and sufficient staff is maintained so that classes are comparatively small, there seldom being more than twenty per instructor with the possible exception of courses in languages. Consequently each student receives a greater amount of personal instruction and supervision than would be possible in a larger institution. Most of the colleges are located in small communities and hence outside distractions are limited. Moreover, living is cheaper in these smaller communities and hence education is cheaper. The average cost per year, to the student, of the engineering course at Mount Allison to-day is from $450 to $550, inclusive of all ordinary necessary expenditures. This contrast with the cost at the larger schools of approximately $1,000 a year is an evident argument in favour of the small college if it can do the work. Again, the engineering student in the early part of his course is part of the community life of a small residential college. This means that these boys are getting their training in the same atmosphere as that which has produced some of Canada's most famous men, such as Sir Robert Borden and Sir George Foster, to mention two only, an atmosphere which is too often missing in the large technical school.

Another great advantage resulting from the close contact between instructor and student is our ability to turn aside into some other more suitable field the man who shows himself

manifestly unfit for engineering practice, without causing him a too great waste of time, as our courses are so arranged that a considerable amount of credit on the regular college courses can be obtained for work taken in engineering. Quite a number of misfits gladly take advantage of this opportunity and enter a field for which they have displayed some aptitude. With the entering student, each year, becoming younger, the advantage to be gained by close and interested contact with the instructors and the resulting strict supervision in the early part of his course, when he is still in his teens, coupled with the quieter life of the small town, and the atmosphere and traditions of these small colleges during one of the important character-forming periods of the student's life, seem to me to far outweigh any advantages the larger institution may have, if the grade of instruction be reasonably good.

In conclusion, permit me to give a few facts concerning the results obtained from this instruction, for the proof of any pudding is in the eating. I will deal only with the time during which I have had personal contact with the system we have been discussing. In the last fifteen years Mount Allison has granted one hundred and forty-one certificates; of the recipients of these, one hundred and four have completed their engineering course elsewhere and twenty-five have transferred to some other field in our own institution, generally Chemistry, Physics, or Mathematics, and graduated in that department. Further, four of the remaining men to-day are successfully practising engineering in subordinate positions on the training secured in obtaining their certificate. Only eight are thus unaccounted for. While many drop by the wayside during the two years, so far as engineering is concerned, a fair proportion of these enter some phase of the arts or other pre-professional courses, as I previously pointed out, so that the time spent cannot be considered a total loss. Moreover, several times men who have not done well in larger institutions have been sent to us, on one occasion by an administrative official of that institution. These men as a rule have been moderately successful in the smaller college if their previous failure had been due to slowness or the distracting

life of the larger institution. However, we in common with all colleges, I presume, get men with whom we can do nothing, and who for one reason or another must be dropped. I make no claim that the small college is a panacea for all student ills, only that some students succeed there who would fail if started in the larger schools. Some few years ago when there was under consideration a scheme of federation of all the small colleges of the Maritime Provinces into one large university in which the N. S. Technical College would become The Faculty of Applied Science, a determined opposition developed among the graduates of the various colleges and not the least among these objectors were our engineering graduates who seemed to feel we would lose far more than we gained. A word as to the product of the central organization, the Technical College. The graduates of this institution now number two hundred and forty, and are scattered throughout all the provinces of Canada, many states of the union and farther abroad. They have succeeded in holding their own and though fairly recently graduated, some of them have even achieved a considerable degree of prominence. There seem to be no more failures among them than among the product of any of the larger colleges run on orthodox lines. Therefore we who have been engaged in carrying on this experiment after twenty-five years feel that we may justly claim it has been successful.

While no set of conditions similar to those which caused the founding of the Nova Scotia Technical College is likely to arise here in the United States, it seems probable that a good deal of the burden now carried by the faculties of applied science of the universities and by the large technical schools could be carried by the small college at a profit both to itself and the large university, as well as to the student. The larger body would be relieved of the necessity for supplying acommodation for so many students in the early years of its course and the smaller institution would exert a directive influence on the immature student. In this way it would appear that the small college has a distinct field in engineering education.

REPORT OF COMMITTEE NUMBER 30, ORIENTATION AND ENGINEERING PROBLEMS COURSES.

An informal meeting of those interested in Orientation and Engineering Problems courses was called at the Iowa City Convention last year for the purpose of comparing methods and discussing difficulties. There was an unexpectedly large response to the call, some 40 members being present at the meeting, which was held in the Old Capitol Building. So much interest was shown in the subject that the Council was requested to appoint a committee for making a special study of these courses. The request was granted and a committee of five appointed.

TABLE I.

District.	Questionnaires Sent Out.	Replies Received.	Number Giving One or Other of the Courses.	Number Giving Neither Type of Work.	Giving Engineering Problems.	Giving Orientation.	Giving Both.	Planning on One or the Other.
New England & New York	25	21	7	14	4	3	1	0
Alleghany	27	21	6	15	1	5	0	1
North Central	32	26	19	7	5	16	2	2
Southern	24	21	11	10	5	7	1	4
Western	25	20	12	8	6	7	1	4
Totals	133	109	55	54	20	38	5	11

This committee organized immediately after the close of the convention and has been collecting data during the past nine months. It is able to make a progress report at this time.

The members of the committee are from very widely scattered schools and therefore it was decided to divide the country into sections such that each man would have about the same number of colleges on his list. Table I gives the data on questionnaires sent out and replies received from the

various sections, and the map shows the geographical distribution of the schools offering these courses.

It was soon evident that the study would divide into two main parts as there is a great difference between Engineering Problems and Orientation courses. While there may be occasional exceptions, there is one important difference between the two types of work. Generally speaking, the Orientation courses require only a small amount of work on the part of the student, but Engineering Problems demands close attention and persistent effort. The Orientation courses almost without exception consist of short, illustrated lectures given to large groups. The Problems classes usually have longer periods in which small numbers are actively engaged in solving problems under the direct supervision of an instructor.

On account of this difference the courses will be discussed separately.

Engineering Problems Courses.

There are six main questions which are usually asked by a person who is interested in the Engineering Problems courses. They are:

1. What are the objectives of the course?
2. How is the work conducted?
3. What is the nature of the problems used?
4. What results are noted? How do students and faculty regard the course?
5. How much time is given to the work?
6. What are the details of its administration?

The experience of the 20 schools which are now offering studies of this type will give more or less satisfactory answers to these questions and thus perhaps be of assistance to anyone planning upon introducing such a course. They will be treated in turn.

1. What are the objectives of the course?

The answers received indicate that there is no single aim but rather that training should be given along several lines. The objectives rank in about this order.

a. Practice in solving problems is important in all of the colleges.

b. Training in systematic methods of attacking and recording problems. Drill in doing neat, clear work. These things are emphasized in the 20 colleges.

c. Training in good habits of work and study. Mentioned by 16 colleges.

d. Orientation of the student. (In 13 colleges.)

e. Coordination of two or more courses. (In 7 colleges.)

The replies received by the committee indicated that all of the schools combined two or more of these aims because a problem can readily be used as a vehicle for all five of the listed objectives.

2. How is the classwork conducted?

Complete data are not available in regard to the methods used in presenting the subject matter of the course. In a number of colleges, however, the discussion method is in use for presenting and developing a new topic. The instructor draws upon the experience of the students in bringing out the basic principles involved in a problem and reduces his own statements as much as is feasible. Practical engineering situations from various fields are used as the sources of problems. The sections are kept small so the students can receive individual attention. Under this system, the class meetings, usually two or three hours long, become combinations of recitation and laboratory periods.

A few places are using text books but when one is used it is more a reference book than a book for assignments and study. Some schools use mimeographed notes in place of a text. Several others are making use of books on "How to Study" during a part of the term. In order to develop interest and secure greater unity of action several colleges hold frequent conferences of the instructors. Some schools do not use any text but do make use of outlines prepared for the teacher.

3. What is the nature of the problems used?

The problems are taken from various fields of engineering. They are either typical, possible situations or else are actual cases taken from practice. It is obvious that many problems have to be simplified in order to make them suitable for use in freshman or sophomore classes. The range of subject matter is wide. They deal with the machine shop, the tool-maker's problems, surveying, construction, material handling, pumping and power plants, electricity, structures, costs and many other topics.

At least 15 schools are emphasizing the applications of mathematics, 13 use elementary mechanics, 12 use problems from physics, 10 use electrical problems and 9 are making use of surveying as motivation for the class work. Four colleges are definitely coordinating two or more other courses by means of Engineering Problems. Several schools give instruction on the operation of the slide rule and one or two have given instruction in the use of computing machines.

4. What results are noted? How do students and faculty regard the course?

The first of these two questions is naturally the hardest to answer since it is difficult to prove that any given result is to be credited to a particular course. Several schools, however, report that the training in neatness, clearness and system is well worth the time spent even though no other gain could be noticed. Others say that the improved quality of the work done by the men in their later years in college is very marked and further state that more advanced work can be given to the students who have had the Problems courses. Two colleges report that men coming from other institutions without this training are under a severe handicap. These men usually do not know how to organize their written work or plan their studies and hence do not get as much out of their classes as do the other students.

Opinion regarding the effect on the number of condition and failure grades is divided but the majority of answers state that there is little effect. A number qualify this com-

ment, however, by saying that it is possible to pick the failures much earlier in a term. Many of the colleges say that the course is helpful in discovering and holding the interest of the better men.

On account of the results which can be definitely ascribed to Engineering Problems, all of the schools offering the course regard the study as a valuable part of the engineering curriculum. Of the 20 schools giving it 13 say that it is "very desirable" and 7 state that it is "worth while."

Most of the colleges gave a statement of student opinion and only two of these reported adverse criticism. In both instances the students said that the work was too hard but even these said the course was worth while.

Over half of the colleges apparently try to have the majority of the classes taught by the older, more experienced men on the staff. It is quite generally felt that the younger students should become acquainted with these men, to feel that the older engineers are interested in beginners and are willing to help them get started. Most of the colleges are using teachers who rank as associate professor or above but nine are using instructors and assistant professors. The policy of using the older men does not seem to be successful in some colleges. For example, one dean reported as follows:

"Most teachers feel that the teaching of freshmen is beneath their dignity and only a few are interested in taking this up as their first choice."

And again:

"The majority of the best teachers feel that they are sacrificing their time when teaching freshmen as they are interested in their specialties."

At least one school is making no attempt to use teachers from the higher ranks because of this lack of sympathy and the younger men are trained for this type of work.

5. How much time is usually given to the work.

The time which is allotted to Engineering Problems varies greatly and evidently depends largely upon local conditions. The time and credits given are as follows:

TABLE II.

TIME AND CREDITS GIVEN FOR ENGINEERING PROBLEMS COURSES.

Year Course is Given		Terms			Meetings per Week		Length of Periods		Credit Given	
No. Colleges	Year Given	No. Colleges	Quarters	Semesters	No. Colleges	Meetings	No. Colleges	Hours	No. Colleges	Credits
18	First	1	1		11	1	9	1	9	1
		7	2		3	2	4	2	4	2
8	Second	1	5		5	3	8	3	8	3
		8		1	1	4	1	1 & 2	1	4
		8		2	1	Varies	1	1 & 3		
							1	Varies		

6. What are the details of administration?

Engineering Problems is a "service course" in 13 of the schools and departmental in 7 of them. The term service course is used to describe courses, such as mechanics, which are required of all students and in which there is seldom any attempt to group them according to departments. In three colleges the work is in a department of General Engineering under the dean of the college; in three others a committee is in charge; in all the rest some one department directs the work. As a rule, one man is put in complete charge and in all except six schools he ranks professor or above.

When the work is given as a service course the instruction staff is usually made up of men drawn from the various departments. There is only one school in which any one puts in full time on Engineering Problems. In this college two men in the department of General Engineering devote all their time to the course and in addition to them from four to twelve additional teachers are borrowed from other departments according to the enrollment.

ORIENTATION COURSES.

The data received regarding these courses can be discussed under the same headings used in reporting on Engineering Problems.

1. What are the objectives of the course?

The Orientation courses or Technical Lectures, as they are sometimes called, are intended to give the student an idea of the various activities included in the term "engineering" and to assist him in deciding upon the particular branch he will elect to follow. Effort is made to acquaint him with the achievements of engineers and to implant the ideals and ethics of his profession in his mind and heart.

2. How is the work conducted?

In all except 7 of the colleges making reports, the time is given to lectures which are often illustrated with slides or motion pictures. The lectures may be given by the dean of engineering, by representatives from each department or by men from industry. In 6 schools assigned readings and some recitation work is given in connection with the lectures. One or more of the colleges use some of the time for short inspection trips.

3. What is the nature of the subject matter?

As stated above, the lectures are largely inspirational and informative in their nature. Most of them are confined to engineering activities. About 25 per cent of the colleges, however, are giving a number of lectures on "How to Study." Other topics which are used are: "Purpose and plan of the engineering courses," "History and achievements of the University," etc. One school endeavors to give some broader contacts and some of their lectures touch upon astronomy, geology and English literature.

4. What results are noted? How do students and faculty regard the lectures?

Some colleges report that the course seems to have some effect in reducing the number of condition grades and failures, but an equal number say that there is no difference. Only 12 answers were received regarding the value of the course for holding the better men and eliminating some of

the unfit but 9 of them said it helped. About the same number said that the effect on later courses was good, that interest was increased and transfers after the first year were reduced.

Twenty colleges reported on student opinion and 16 of these said the lectures were liked, that the men were interested and considered the talks served a useful purpose. The other four schools said that the men did not like the course or else considered it as of nominal value.

There is not the unanimity of opinion concerning the success of the present methods of conducting the Orientation courses that there is about the Engineering Problems classes. Although 22 colleges stated that they considered that the lectures were worth while, not all were completely satisfied with the operation of the course, as is shown by their answers to the question, "How does your present plan work?" The answers were:

Excellent	3	colleges
Good	5	"
O.K.	5	"
Fair	4	"
Questionable	2	"

One of the schools placing a rating of "questionable" upon the course is dropping it this year. Three others say that they once offered it but dropped it because the returns did not justify the time spent. Several letters from colleges not giving such lectures at present indicated a great deal of doubt regarding the value of the course in aiding the students in choosing their courses of study. It was stated that few men ever changed their plans as a result of listening to lectures.

5. How much time is given to the work?

The following summary gives this information.

TABLE III.

TIME ALLOWANCE AND CREDITS FOR ORIENTATION COURSES.

Year Course is Given.		Terms.			Meetings per Week.		Length of Periods.		Credits Given.	
No. Colleges.	Year Given.	No. Colleges.	Quarters.	Semesters.	No. Colleges.	Meetings.	No. Colleges.	Hours.	No. Colleges.	Credits.
37	First	6	1		32	1	34	1	15	0
1	Third	2	2		3	2	2	2	6	1
		4	3		1	3	1	3	4	2
		15		1	1	5			2	3
		10		2	1	2 per month			1	5
		1		6						

6. What are the details of its administration?

Information on this subject was not very complete but some data regarding the men in charge was obtained. Of the colleges offering the work 33 reported as follows:

No. of Colleges.	Course Directed by
21	Dean of Engineering
2	Committee
2	Department heads
4	Professors
4	Instructors and Assistant Professors

In all but seven of the colleges the lectures are given as a service course. Seven departmental courses have been included in this tabulation but it may be that they should not be counted since their lectures are usually concerned with only one field of engineering.

CONCLUSIONS.

The foregoing summary of the returns received from the colleges will indicate what has been done along the line of special courses for freshmen and sophomores. This committee has not had the time to make a study of the details of subject matter and teaching methods nor is it ready at this time to make any recommendations. There are a few con-

clusions which may be drawn, however, and they may be of interest to any one who may be considering the introduction of either of these courses.

1. That there is a wide difference in the aims of the Engineering Problems and Orientation courses.
2. That while Engineering Problems courses can be of considerable help in aiding the student to find himself, it should not be regarded primarily as orientation work but rather as a training course for preparing the student for the advanced courses in engineering.
3. That the Orientation lectures must be carefully planned but they can be made to meet a need when the topics are chosen so they will give the students a clear idea of the scope of each branch of engineering.
4. That utmost care should be used in selecting the teachers and lecturers for both types of courses.

Respectfully submitted for the committee,

C. W. BEESE,
J. J. RICHEY,
E. H. ROCKWELL,
E. R. WILCOX,
E. H. WRIGHT,
FOREST C. DANA, *Chairman.*

BIRTHDAY GREETINGS.*

G. B. Pegram: Some of us have been conducting a little investigation, being moved to it by what appears to be a misprint in the June issue of our JOURNAL. The investigation is as to the age of our President. I very carefully approached a number of members of this Society—as a good many of you know—to find out what the age of the President is. I received estimates all the way from forty-two to forty-seven years. The average (and of course you know with a sufficient number of observers, you can approximate pretty closely the truth) is between forty-four and forty-five.

This is rather upsetting to the plan the members of the Society had to say something "with flowers" to our President on his birthday, because if the statement in the Journal is so erroneous as to the year in which he was born, it may well be erroneous as to the day on which he was born. Nevertheless, the thing has gone so far we cannot stop it now.

Knowing of the interests and likes of our President, it seemed most appropriate to give our congratulations to him on his alleged birthday accompanied by flowers. I understand one of his regrets is that in his duties as Dean and as President of this Society and otherwise, he has not time to stay home and look after the surroundings of his house the way he would like to. When he was at Ithaca, he built a house and paid a great deal of attention to the surroundings and the flowers which should encompass him. Therefore we should mark our special congratulations with flowers, and following the printed record rather than the much better estimate of our Society, we pass this bouquet to him with the felicitations of all the members of the Society on his successful completion of the first year of his second fifty.

* Presented at 35th Annual Meeting of the Society, University of Maine, June 28, 1927.

President Leland: It is a year ago today actually (of course I do not know how accurate the records are, but ever since I can remember it has been the 28th day of June, and I can remember back far enough so that I guess probably the years are correct) since one of my children offered the very unusual remark, "Dad is half a century old."

So when a man has passed the peak and begins to go down on the other side, if it is down, or up on the other side, if it is up, he may begin to get a little sensitive. I do not suppose he gets quite so sensitive as his wife might get, but nevertheless he has to get used to it, by that time.

I have not anything to say. I simply feel very highly gratified at this evidence of the good taste of the members of the Society in giving me men's flowers, that is, carnations, instead of the roses they are accustomed to put on graves. I am glad also that I am getting them in advance, this way. I hope that this is not in preparation for my immediate departure. I do wish to express my appreciation. It is a very fine thing for a man to receive flowers. He does not very often, I think, and I certainly appreciate the consideration and thoughtfulness of the Society. I wish to say also that this gavel is engraved with my name, so I think that I may assume that that is a permanent acquisition and also a birthday present.

REMARKS BY PRESIDENT-ELECT.*

R. L. Sackett: Mr. President, Members of the Society: I assure you I appreciate very much this expression of confidence on the part of the Nominating Committee. I should not be so unseemly as to inquire into the specifications of a president. I noticed that age was emphasized considerably in a very pleasing fashion. Perhaps they inquire also into color and previous condition of servitude.

I can only say again that I do appreciate very much the honor, and I also appreciate somewhat the responsibilities that fall on one under these particular circumstances. I have been very much interested naturally in the investigation which has been carried on. We are now approaching the time when if this investigation is to yield in dividends that which we expect, we must mould into our academic body something of the results, and as we approach that period of moulding, I see for us, of the Society, a larger responsibility. The Board of Investigation and Coordination has carried a large measure of this responsibility up to the present time.

Now, it seems as if we must weld ourselves into this movement even more closely than we have in the past. I therefore appeal to you to assist during the next year in bringing to a logical conclusion this movement into which the Board and the investigating authorities have put their souls.

* Presented at the 35th Annual Meeting of the Society, June 27–30, 1927.

FAREWELL.*

BY H. S. BOARDMAN,
President, University of Maine.

All I can say at this time, is to express my appreciation of the large gathering which we have had at the institution. I think that it is a great satisfaction to all members of the Engineering Staff at the University and also will be to all of the rest of the Staff to know that this has been a record meeting. It is something which we had not expected and is a great gratification to us. Last night, the Governor confided in me that he had had two hours' sleep in the past forty-eight hours and I took him home and put him to bed and tucked him in. Shortly after he left the banquet hall, he told me that on his way over from Augusta he was thinking to himself, "I am glad to go over there, but is it really going to be worth while to speak to the small body of hard-boiled professors which will probably be assembled, as not many will probably find it in their way to come from so great distances." He said, "When I got there and saw that aggregation, I could hardly speak." He was very much gratified, and I think that the keynote which he sounded on that occasion is one which will long be with us.

I hope that you will all come to Maine again and that you will all not fail to come to the Institution when you do come into the state. In bidding you farewell, I am simply doing it for one year, because Mrs. Boardman and I expect to motor to the meeting next year.

* At 35th Annual Meeting, University of Maine, June 30, 1927.

SYMBOLS FOR HEAT AND THERMODYNAMICS.

Prepared by Sub-Committee, American Engineering Standards Committee,

SANFORD A. MOSS,

Chairman.

General Principles.

1. In most cases the same symbol shall be used, regardless of systems of units. Thus v is specific volume, whether cc. per gram, cc. per mol, cu. ft. per lb., etc.

2. In cases where more than one system of units is used in a discussion, a single symbol may be used, with addition of subscripts, superscripts, or indices to denote units other than the primary one, such as, p, p_t, p', p''. (Sometimes, however, capital and small letters may distinguish units. See Par. 7.)

3. The same symbol should be used for a given concept, regardless of the number of special values which occur, and subscripts or superscripts should be used to designate them.

4. Letter subscripts should be used to denote values under special conditions or at special states, such as,

C_p or c_p = specific heat at constant pressure.
C_v or c_v = specific heat at constant volume.
η_t or e_t = thermal efficiency.
η_m or e_m = mechanical efficiency.

5. Numerical subscripts should be used to denote values at designated points in an apparatus, process or cycle, such as,

p_1 = initial pressure.
p_2 = final pressure.
W = weight of a major item.

$W_1, W_2, W_3, \cdots$ = weights of auxiliary items.

6. In order to increase the clarity of printed matter, which is practically always Roman, symbols alone or in equations should be printed in Italics.

7. Where possible, capital letters denote total quantities and small letters denote specific quantities, or quantities per unit. Thus,

S may be entropy of any weight, and
s may be entropy of unit weight.

Sometimes however, capital and small letters may distinguish units. Thus P may be total pressure and p partial pressure, or P may be lbs. per sq. ft. and p, lbs. per sq. in., or capitals may be values per mol, and small letters values per gram or per pound.

SYMBOLS.

p or P = pressure, absolute or gage (force per unit area).

v = specific volume (volume per unit weight) $= 1/d$.

d or v^{-1} or $1/v$ = density (weight or mass per unit volume).

C or c = specific heat.

C_p or c_p = specific heat at constant pressure.

C_v or c_v = specific heat at constant volume.

k or κ = ratio of specific heats $= c_p/c_v$.

Q = total quantity of fluid, water, gas, heat, light or electricity, total volume.

q = flow rate, volume rate per unit of time, rate at which quantity of material passes through a machine, quantity of heat per unit time or unit weight.

F = force or pressure on a total area, total load.

A = atomic weight.

A = area or surface.

M = molecular weight (M is also used for moment of force).

m = mass $= W/g$.

W = total weight.

w = flow rate, weight rate, weight per unit of power or unit of time.

w = quantity of work or mechanical energy per unit weight.

W = total quantity of work or mechanical energy.

P = power or horsepower, or energy per unit time.

E = energy.

J = mechanical equivalent of heat.

A or J^{-1} or $1/J$ = heat equivalent of work.

t = time.

t or θ = thermometric temperature ° F. or ° C. (θ is preferably used only when t is used for time in the same discussion).

T = absolute temperature ° F. or ° K.

S or s or Φ or ϕ = entropy. Preferably, the capitals are used for any weight, and small letters, for unit weight.

U or u = internal or intrinsic energy. Preferably, the capital is used for any weight, and the small letter for unit weight.

H or h = heat content, total heat or enthalpy $= u + (A)pv$. Preferably, the capital is used for any weight and the small letter for unit weight.

ψ = Helmholtz free energy or internal potential function $= u - Ts$.

ξ or Z = Gibbs function or total potential function (sometimes called free energy) $= u + (A)pv - h - Ts$.

Sub_f = denotes saturated liquid (fluid) at saturation pressure and temperature (liquid in contact with vapor).

Sub_g = denotes dry and saturated gas or vapor, at saturation pressure and temperature (vapor in contact with liquid).

This system, carried to a logical conclusion, requires also subscripts for liquid in contact with solid, solid in contact with liquid, solid in contact with vapor and vapor in contact with solid. However, these are not assigned at this time.

Sub_c = denotes conditions at critical point.

Sub_{fg} = denotes vaporization values, or differences between values for vapor and liquid at saturation conditions.

The other pairs of subscripts mentioned above, when assigned, might be used to denote values for fusion or melting, and sublimation.

h_f = heat content, total heat, or enthalpy of saturated liquid, or heat of the liquid.

h_g = heat content, total heat or enthalpy of dry, saturated vapor or gas.

v_f, v_g, v_{fg}, etc. = various values for saturation and vaporization, according to above rules.

p_f and T_f or p_g and T_g = saturation pressure and temperature.

L or l or h_{fg} = heat of vaporization.

L or l or h = with subscripts, may also be used to denote heat of fusion or heat of sublimation.

R = gas constant in equation $pv = RT$. Two values are in customary use. The first is the universal constant, corresponding to v in the above equation as volume per mol (product of molecular weight and volume per unit weight). The second is the particular value for a given gas, corresponding to v as volume per unit weight. The second value is the first value divided by molecular weight M. If desired, a prime or a subscript may be used to distinguish between the two values.

C = concentration, amount of a particular constituent per given amount of mixture.

x = quality of steam, pounds of dry steam per pound of mixture.

n = exponent of polytropic expansion in expression

$$pv^n = \text{const.}$$

p_m = mean effective pressure.

G = specific gravity, referred to air for gases and to water for solids and liquids.

g_o = standard value of acceleration of gravity = 980.665 cm./sec.^{2} = 32.1740 ft./sec.^{2}

g = local value of acceleration of gravity. For most engineering work

the distinction between g and g_o is negligible and g may be used to represent either value without distinction.

e or η = efficiency.

N = revolutions per unit time.

ω = angular velocity. (ω is also used in other lists for solid angle.)

l, x or s = length or distance.

C or K = coefficients or constants.

V = velocity.

D = diameter.

r = radius.

μ = Joule Thomson coefficient $(dT/dp)_h$.

μ = viscosity.

$Y = (P_1/P_2)^{1-1/k} - 1$ = adiabatic factor.

REGULATIONS RESPECTING THE LAMME AWARD.

The following regulations were adopted by the Council at the 1926 meeting. Action was delayed due to the difficulties encountered in securing the dies, etc. The Executive Committee has voted to bestow the first medal at the 1928 meeting. A committee has been appointed to select the candidate for the medal.

The will of the distinguished inventor and chief engineer of the Westinghouse Electric & Manufacturing Company, Mr. Benjamin G. Lamme, contained a provision as follows:

"I hereby authorize and empower my said executors and trustees to pay over to or place in trust for the Society for the Promotion of Engineering Education, or some other suitable body acting for the technical schools of this country (the beneficiary of such trust to be selected by my said executors and trustees), the sum of six thousand dollars ($6,000) of which an amount not exceeding one thousand dollars ($1,000) shall be expended for a die and the balance shall be held as a trust fund, the yearly income from such fund to be expended for a suitable gold medal (together with a bronze replica thereof) to be given yearly to a chosen technical teacher for accomplishment in technical teaching or actual advancement of the art of technical training. If the accumulation of said trust fund, in the judgment of said beneficiary, warrants, then in some years two medals may be given. No individual shall receive such medal more than once."

The foregoing provision was associated in Mr. Lamme's will with provisions of a similar nature for medals for meritorious achievement in the development of electrical apparatus or machinery to be conferred by the American Institute of Electrical Engineers; for medals to graduates of one of the technical departments of Ohio State University for meritorious achievements in engineering or technical arts to be conferred by that university; and for scholarships during their senior year to be conferred on the two most capable students in mechanical and electrical engineering courses at the Ohio State University.

The foregoing quotation from the will names the Society for the Promotion of Engineering Education, or alternatively, "some other suitable body acting for the technical schools of this country" as the beneficiary, this beneficiary to be selected by the executors and trustees of the will. The executors and trustees have now selected the Society for the Promotion of Engineering Education as the beneficiary of the trust and the Society has accepted the duties of the trust. The devised fund of six thousand dollars ($6,000) less inheritance taxes amounts to a net sum of five thousand, one hundred sixty dollars ($5,160) which the executors of the will have paid over to the Society and that sum is now held by the Society as a special trust fund for the purpose of the Lamme award.

The committee appointed on the Lamme award recommend the following rules for the administration of the award.

1. There shall be provided a medal of gold, called the Lamme Medal for Achievement in Engineering Education, in accordance with the provisions in the will of B. G. Lamme. When awarded it shall be accompanied by a bronze replica struck from the same die. The obverse of the medal shall be in commemoration of Mr. Lamme.

2. The award of the medal shall be made by a committee of twelve members with terms of four years each, known as the Committee on the Lamme Award, three members being appointed to the Committee by the retiring President with the approval of the Council at each annual Convention of the Society, the terms to begin at the expiration of that Convention; except for the original committee which shall consist of twelve members appointed by the President with the approval of the Council at the Annual Convention of 1926, three of these members to be designated for a one-year term, three to be designated for a two-year term, three to be designated for a three-year term, and the remaining three members being designated for the full term. These Committee members shall be chosen at large from the membership of the Society and the desirability of the representation of the different branches of engineering should not be overlooked in the selection of Com-

mittee members nor should the desirability be overlooked of the representation of practicing engineers and industrialists among the Committee membership. Any person who has served one or more years as a member of this Committee shall not be eligible for reappointment until at least four years have expired since the termination of his preceding membership.

3. The By-Laws of the Committee shall be prepared by the first Committee appointed (namely, the membership as appointed at the Annual Convention of 1926) and be submitted to the Council for approval. They shall provide for the selection of the recipient of a medal or the recipient of each one of two medals by an annual preliminary or nominating ballot the results which shall be reported to all the members of the Committee and may be discussed at a meeting of the Committee. The selection of a name for final ballot for the award of a medal shall be made by letter ballot from between not less than two or more than four names receiving the highest votes in the nominating ballot relating to that medal. The name receiving the highest vote for each award shall go to final letter ballot which shall be secret, and this final ballot shall be opened and canvassed only by the Committee on the Lamme Award in a formal meeting at or before the Annual Convention at which the Award shall be announced. For the purpose of this meeting of the Committee, four members shall constitute a quorum. A final selection shall fail and the award lapse for the year unless the nominee receives not less than eight affirmative ballots, namely, the affirmative ballot of not less than two thirds of all members of the Committee.

4. The dies for the medal shall be deposited with the Superintendent of the United States Mint at Philadelphia, in trust, exclusively for the above purposes.

Committee: CHARLES F. SCOTT,
F. L. BISHOP,
DUGALD C. JACKSON, *Chairman.*

LOCAL (UNIVERSITY OF NORTH CAROLINA) COMMITTEES FOR S. P. E. E. MEETING, JUNE, 1928.

General Steering Committee: G. M. Braune, P. H. Daggett, Archibald Henderson, E. G. Hoefer, A. C. Howell, G. W. Smith, Thorndike Saville, *Chairman.*

Committee on Entertainment: P. H. Daggett, *Chairman,* H. G. Baity, J. M. Bell, O. J. Coffin.

Committee on Finance: G. M. Braune, *Chairman,* P. H. Daggett, C. T. Woolen.

Committee on Housing and Transportation: E. G. Hoefer, *Chairman,* A. W. Hobbs, J. B. Linker, E. K. Plyler, R. M. Trimble.

Committee on Reception: Archibald Henderson, *Chairman,* H. G. Baity, W. F. Prouty, J. W. Lasley, Jr.

Committee on Registration: A. C. Howell, *Chairman,* T. F. Hickerson, R. M. Trimble, F. C. Vilbrandt.

Committee on Rooms and Equipment: G. W. Smith, *Chairman,* J. M. Foushee, C. E. Ray, Jr., A. S. Windsor.

Committee on Ladies' Entertainment: Mrs. G. M. Braune, *Chairman,* Mrs. Harry Chase, Mrs. P. H. Daggett, Mrs. Archibald Henderson, Mrs. E. G. Hoefer, Mrs. H. F. Janda, Mrs. A. H. Patterson, Mrs. Thorndike Saville, Mrs. C. T. Woolen.

Encyclopædia Brittanica: The Secretary of the Society, F. L. Bishop, has been invited to write, for the new edition, the article on "Engineering Education in America."

NEW MEMBERS AND SECTIONS.

BIDWELL, CHARLES C., Professor of Physics, Lehigh University, Bethlehem, Pa. C. R. Richards, F. L. Bishop.

BOETTCHER, ARNOLD A., Instructor in Mechanical Engineering, Oregon State College, Corvallis, Ore. H. S. Rogers, F. L. Bishop.

CURFMAN, LAWRENCE E., Professor of Civil Engineering, Kansas State Agricultural College, Manhattan, Kans. L. W. White, M. W. Furr.

GRANDY, LEWIS S., Associate Professor of Electrical Engineering, University of Mississippi, University, Miss. W. E. Wickenden, C. F. Scott.

HILL, RALPH E., Head, Mathematics Department, University of Louisville, Louisville, Ky. B. M. Brigman, W. B. Wendt.

MOCKMORE, CHARLES A., Assistant Professor of Civil Engineering, Oregon State Agricultural College, Corvallis, Ore. H. S. Rogers, R. H. Dearborn.

MOORE, RALPH W. E., Engineering Manager, Association Activities, Westinghouse E. & M. Company, East Pittsburgh, Pa. C. F. Scott, C. S. Coler.

OWENS, HERBERT D., Teacher of Unit Trade, Electricity and Industrial Mathematics, McKeesport High School, McKeesport, Pa. F. C. Caldwell, J. E. Shepardson.

SUMMERS, ERWIN R., Instructor in Electrical Engineering, University of Minnesota, Minneapolis, Minn. W. E. Brooke, O. M. Leland.

Total new members this year, 112.

Kentucky Section—27 representatives met at the University of Louisville on December 17. Those representatives were from the University of Kentucky, the University of Louisville, and Evansville College. Officers elected were:

W. B. WENDT, *Chairman,* Univ. of Louisville.
W. EDWIN FREEMAN, *Vice-Chairman,* Univ. of Kentucky.
MAX B. ROBINSON, *Secretary and Treasurer,* Evansville C.

South Dakota Section—Organization meeting January 13, 1928. Project: "That of helping the high school students to become vocationally intelligent about the profession of engineering." Officers elected were:

H. M. CROTHERS, *President,* S. D. State College.
J. O. KAMMERMAN, *Vice-President,* S. D. School of Mines.
L. E. AKELEY, *Secretary-Treasurer,* Univ. of S. D.

SECURE THAT NEW MEMBER NOW!

Return to the Secretary, F. L. Bishop, University of Pittsburgh, Pittsburgh, Pa.

SOCIETY FOR THE PROMOTION OF ENGINEERING EDUCATION.

Date.....

THE UNDERSIGNED desiring to become a member of

THE SOCIETY FOR THE PROMOTION OF ENGINEERING EDUCATION

hereby agrees to conform to the requirements of membership, if elected, and submits the following:

STATEMENT OF QUALIFICATIONS

Full Christian Name and Surname.....

Residence Address (Number and Street).....

Post Office (City and State).....

Full Title of Professional Position.....

Full Name of Institution.....

(To be Signed by Two Sponsors)

SPONSORS { .....
.....

1928 YEAR BOOK.

Each member has received a card asking him to print or typewrite his name, position, and address for publication in the year book of the Society. These cards are to be returned immediately to the office of the Secretary.

If you have not received your card, or have mislaid it, will you please fill out the card below and send it to the Secretary, F. L. Bishop, University of Pittsburgh, Pittsburgh, Pa.

(Name) (Position)

(City) (State)

I should like to be classified as indicated by √ below:

Administrative	Educational ( )	Industrial Engineering.....	( )
	Industrial.. ( )	Machine Design and Drawing	( )
Aeronautics	( )	Mathematics	( )
Agricultural Engineering....	( )	Mechanical Engineering....	( )
Architecture	( )	Mechanics and Materials...	( )
Chemical Engineering.....	( )	Metallurgy	( )
Chemistry	( )	Mining and Geology.....	( )
Civil Engineering.....	( )	Physics	( )
Economics	( )	Psychology	( )
Electrical Engineering.....	( )	Sanitary Engineering.....	( )
English	( )	Shop & Mechanic Arts.....	( )
Foreign Language.....	( )		

IS THE SOCIETY KNOWN?

The Secretary recently received a letter from Leningrad, Russia, which had been addressed to

"The Journal of Engineering Education,
Lancaster,
England."

COLLEGE NOTES.

Each month under the heading "College Notes" there is published in the JOURNAL items of interest which are submitted by some member who is interested, not only in the work of the Society, but also in the changes in his own institution. Not all the institutions are represented in this group. There have been changes in the personnel of your faculty, in your curriculum, new equipment has been added, promotions have been made, etc. Are the other members of the Society familiar with these? For your convenience we are leaving the remainder of this page blank. Fill it out and send it to the Secretary, F. L. Bishop, University of Pittsburgh, Pittsburgh, Pa. If there is not enough space on this page, copy may be sent in which has been written on letterhead. Be sure to sign your name and the institution, the latter for publication, the former for our information. Do this each month, or as often as you can, and keep your institution before the readers of the Society.

Submitted by _____

Date _____

Clemson College, the state A. and M. College of South Carolina now (1927–28) has an engineering enrollment of 525 full-time students in its courses in civil, electrical, and mechanical engineering and architecture. In addition to the above students, the School of Engineering gives much of the instruction to the 125 students now enrolled in the textile department.

Mr. B. L. Fernow, professor of Mechanical Engineering is an addition to the faculty this year.

Professor S. B. Earle, director of the Engineering Department, has been relieved of all teaching duties to enable him to devote all of his time to executive matters.

Mr. James A. Stevenson has been added to the Clemson faculty. He is Assistant Professor of Civil Engineering.

On November 3, 1927, the corner stone of the new engineering building was laid at an effective ceremony. In addition to a brief address by President E. W. Sikes on the place of engineering in our modern civilization, Director S. B. Earle gave an interesting historical sketch covering the whole history of engineering instruction at Clemson College.

Professor R. E. Lee, head of the Architectural Department and architect for the new building, gave a discussion of some of the main features of the structure.

The corner stone committee headed by Professor W. W. Klugh had gathered much interesting material covering the history and personnel of the engineering school, which was placed in the corner stone just before it was lowered to its final position.

The new building is to replace the one destroyed by fire in May, 1926, but is much larger and better adapted to its uses. There has also been built recently a new engineering shop building which is quite large and finely equipped for all branches of shop work.

University of Idaho: F. J. Kelley, Dean of Administration at the University of Minnesota, has accepted the presidency of the University of Idaho.

SECTIONS AND BRANCHES

The Kansas-Nebraska Section.—A large number of the members of the Kansas-Nebraska Section made the trip to Lawrence, Kansas, for the seventh annual meeting held at the University of Kansas, October 14 and 15, 1927. The visiting members began arriving in Lawrence about noon on Friday, October 14. The early part of the afternoon was spent in inspecting points of interest on the campus. At six o'clock dinner was served to the visiting ladies at the Colonial Tea Room and at six-thirty the men gathered for dinner at St. John's Church.

Since a very attractive program had been arranged for the dedication of the new auditorium at the University the men voted to attend at least a part of the dedicatory exercises before beginning the technical session of the evening. These exercises were very enjoyable, especially the musical numbers furnished by the Kansas Glee Club and the Kansas Band.

Evening Session.

The Technical Session was called to order by President L. E. Conrad in Room 206 of the Engineering Building at 8:50 P.M.

The minutes of the Sixth Annual Meeting held at Lincoln November 12 and 13, 1926, were read and approved.

Professor R. G. Kloeffler (K. S. A. C.) was introduced and presented the first subject of the meeting: "The Orono Meeting of S. P. E. E." In addition to discussing the meeting, he also told of some of his experiences in traveling through Canada. Mr. Kloeffler then showed a reel of motion pictures which he had taken at Orono and other points in Maine. Professor Geo. C. Shaad (K. U.) continued the subject, giving some of his personal experiences and observations.

The second subject of the evening, "Sectioning Classes on the Basis of Ability," was presented by Dean O. J. Ferguson

(U. of N.). The discussion on this subject was continued by Dr. J. C. Peterson (K. S. A. C.) and Dr. C. H. Ashton (K. U.). Dean Ferguson discussed the methods used in sectionalizing classes in Freshmen English and Freshmen Chemistry at the University of Nebraska. Since this method has been in use at Nebraska for several years, he was able to point out some of the advantages of such sectioning. He then discussed the sectionalizing of Junior and Senior Electrical Engineering Classes. Drs. Peterson and Ashton continued the discussion, giving some experiences from their respective schools. They also discussed sectionalizing of Freshmen classes on the basis of high school preparation since the Freshmen of the Kansas schools do not all enter with the same amount of high school mathematics. Following these three speakers several other members discussed this subject from the floor.

Before adjourning the evening session, several letters from Mr. Wm. E. Wickenden, Director of Investigation, were read by the secretary.

President Conrad appointed Prof. Geo. C. Shaad, Prof. Geo. R. Chatburn, and Prof. A. J. Mack to act as the nominating committee.

The meeting adjourned at 11:30 P.M.

Morning Session.

The morning session was called to order by President Conrad in Room 206 of the Engineering Building at 8:30 A.M.

The first subject of the morning was "Value of the S. P. E. E. Summer School for Engineering Teachers." This subject was presented by Professor J. H. Robert (K. S. A. C.). Mr. Robert gave a very interesting review of his experiences and reactions at the Wisconsin Session of S. P. E. E. Summer School. Professor R. S. Tait (K. U.) continued the discussion on this subject.

Professor J. W. Haney (U. of N.) presented the second subject of the morning, "Should the Grading of Engineering Students be Standardized?" Mr. Haney discussed the system of grading in use at the University of Missouri and also

the efforts made at the University of Nebraska to secure more uniform grading by different instructors in the same department and by different departments. The discussion of this subject was continued by Professor M. A. Durland (K. S. A. C.) and Professor A. M. Ockerblad (K. U.).

The question of a regional meeting which was raised in Mr. Wickenden's letter was discussed to some extent. Some members favored a regional meeting while others thought that it might detract from the national meeting. Due to lack of time the discussion was limited and no definite answer was reached. It was moved by Professor F. L. Brown (K. U.) that the question of a regional meeting be considered actively by the incoming officers. This motion was seconded and carried.

The Nominating Committee through its chairman, Professor Shaad (K. U.) made the following report.

For President, O. E. EDISON (U. of N.).
For Secretary, R. S. TAIT (K. U.).
Chairman of Program Committee, E. R. DAWLEY (K. S. A. C.).

Professor J. H. Robert (K. S. A. C.) moved that the report of the Nominating Committee be accepted. This motion was seconded and carried.

A motion to adjourn closed the technical session of the Seventh Annual Meeting of the Kansas-Nebraska Section of S. P. E. E.

Following adjournment all the visitors were guests of the K. U. members at luncheon at the Lawrence Country Club. At the close the traditional speeches of the past presidents and president-elect were given. Most of the group attended the K. U.-K. S. A. C. football game in the afternoon.

The Kentucky Section.—On Saturday noon, December 17, 1927, twenty-seven representatives of the engineering faculties of the University of Kentucky, the University of Louisville, and Evansville College met at the Speed Scientific School of the University of Louisville to organize a regional section of the S. P. E. E., to include the colleges above mentioned as

well as others in this territory who might wish to join later.

The business meeting was preceded by a splendid luncheon served by the home economics department of the University, and by a tour of inspection of the engineering laboratories of the Speed Scientific School, of the new administration building and of the newly-opened art gallery recently presented to the University.

The meeting was called to order at 2:30 P.M. with Professor W. B. Wendt of the Department of Civil Engineering, University of Louisville, as temporary chairman. Professor Daniel V. Terrell, Department of Civil Engineering, University of Kentucky, then presented a proposed constitution and by-laws prepared in advance by an informal committee, of which he was chairman.

After some discussion the constitution was adopted as proposed, under the name "Kentucky Section." It was understood that this name might be subject to change at a later date after it became known just what institutions outside the state might decide to affiliate.

The following officers were elected to serve for one year:

Chairman, W. B. WENDT, Professor of Civil Engineering, University of Louisville.

Vice-Chairman, W. EDWIN FREEMAN, Assistant Dean and head, Department of Engineering, University of Kentucky.

Secretary and Treasurer, MAX B. ROBINSON, Director of Engineering, Evansville College.

The formal program for the afternoon consisted of a paper by Director Robinson, "Reducing Freshman Eliminations." As was hoped this precipitated a lively discussion in which a number took part.

Communications were read from Secretary Bishop and from Dean Anderson of the University of Kentucky, expressing regrets at their inability to be present and promising their hearty cooperation in the future.

Representation at this meeting was as follows:

University of Louisville	16
Evansville College	7
University of Kentucky	4

The majority of these representatives were members of the society.

The section plans to have its next meeting at the University of Kentucky in April.

MAX B. ROE,
Secretary.

The Minnesota Section: "Pre-College Preparation for Engineering Students."* L. N. McWhorter, Assistant Superintendent, Minneapolis Public Schools.

During the last decade, public secondary schools have been most interested in the development of the junior high school idea in this country. This idea originated in localities in which there was a strong prejudice in favor of pre-vocational training, and the development of pre-vocational courses and exploratory procedures was very noticeable. In later years, the school has become a general, cosmopolitan institution through which all pupils, irrespective of their future experiences in life, must pass.

Out of this phase in the development of the junior high school has grown the conception that it is to be a basic, general school in which instruction should be offered in all those fields which have a distinct bearing upon the everyday life experiences of the children of the junior high school age. Somewhat traditionally these fields are the field of the social studies, the field of English, the field of mathematics, the field of science, the field of industrial work, the field of physical and health education, and the fields of artistic appreciation and expression. Our courses in the junior high school are emerging along this line, with the added consideration that the junior high school should not begin to prepare specifically for college nor be restricted in its field of instruction by college entrance demands.

* Brief digest of talk given before the Minnesota Section of the Society.

Our figures show that 17.6 per cent of the pupils who enter our elementary grades finally register in some institution of higher learning after graduation from high school. Of these, about half are boys, and I do not know what percentage of these boys find a place in the College of Engineering. The problem, then, becomes one for the senior high school principal to solve; and as the junior high school is becoming more and more an institution of general and fundamental training, so the senior high school, for pupils who are entering engineering colleges as well as pupils who are going immediately into business or industry, must, through newly developed departments of research, guidance, and placement, study carefully the requirements and qualities essential in all these fields.

It would seem to me that a high school principal should have definitely in mind the following qualities as desirable in a student who was preparing to take an engineering course and eventually to enter the engineering profession:

1. An aptitude for industrial and scientific work.
2. A close application to details.
3. A mind satisfied only with accuracy.
4. A facility in computational, mechanical, and graphic skills.
5. A creative instinct and a broad visioning power, with a wealth of imagination.

In the traditional fields of instruction there are three which deserve special consideration. They are, first, the field of mathematics, second, the field of specific industrial preparation, and third, the field of the social studies. We fully recognize that in none of these fields at present do we offer preparation that is fully adequate or absolutely satisfactory for students entering colleges of engineering. It is our feeling, however, that we should develop courses in mathematics in which the emphasis upon the more difficult concepts of algebra should be taught at a point much nearer the entrance to college than the ninth grade, where algebra has been taught for many years; second, that we should throughout the senior high

school, by some procedures, maintain skills in the use of common tools and in the graphic arts that will carry over into the experiences of the engineering college; and third, that that type of social study should be experienced by the senior high school pupil which will give him a better understanding of the social, economic, and civic problems of the day through the studies of sociology, economics, world history, and civics, rather than the more classic phases of this field.

South Dakota Section.—As a result of considerable correspondance with Professor W. S. Rodman, Committee on Sections and Branches of the S. P. E. E., the South Dakota Section was organized at Sioux Falls, January 14, 1928. The following officers were elected for the ensuing year.

President, DEAN H. M. CROTHERS of the South Dakota State College at Brookings.

Vice-President, PROFESSOR J. O. KAMMERMAN of the School of Mines at Rapid City.

Secretary-Treasurer, DEAN L. E. AKELEY of the University of South Dakota at Vermillion.

The project which the South Dakota Section resolved to undertake is that of helping the high school students to become vocationally intelligent about the profession of engineering. South Dakota is not an industrial state. The high school students in this state have seen very few engineers, and very few engineering projects. This project of vocational guidance, as regards engineering, we believe is the most urgent call that the engineering colleges of this state can consider.

We have made our organization very simple and very informal. One member of the faculty of the Washington High School of Sioux Falls is a member of the national organization. There are four engineering graduates in the Sioux Falls High School, and they attended our session and took part in our discussions. The cooperation of the high school men of the state is indispensible to the working out of the project that the South Dakota Section has undertaken. We expect to put some high school men upon the program next year.

This meeting came at the close of the meeting of the State Engineers and Architects, whose annual meeting came to a close Friday, January 13, at noon. The time of the meeting of the section of S. P. E. E. had been arranged to accommodate those members who wished to attend the meeting of the architects and engineers. It was hoped that the double attraction of the architects and engineers meeting, and the new section of the S. P. E. E., would attract to Sioux Falls as many members as possible of S. P. E. E. in South Dakota.

The paper by Dean Crothers of Brookings, who is president of the section, was on the subject of "Vocational Guidance;" the paper by Professor Kammerman upon "Some Phase of Laboratory Instruction;" the paper by Professor J. Maughs Brown on "The Engineering College in the Service of the State." Each paper was followed by a discussion by the whole membership.

ADDRESSES WANTED.

If you know the present address of any of the following members of the Society, will you please send it to the Secretary, F. L. Bishop, University of Pittsburgh, Pittsburgh, Pa.

Baker, Cecil F.
Barr, Harold A.
Bailie, Jos.
Drum, T. S.
Earle, Chester R.
Frautz, R. W.
Hoot, Clarence E.
Kerr, Joseph
Laur, Fred. J.
Linville, C. P.
Maitland, T. J.
Moss, J. D.
Richardson, M. R.
Smith, W. L.
Tozer, E. F.
Young, S. K.